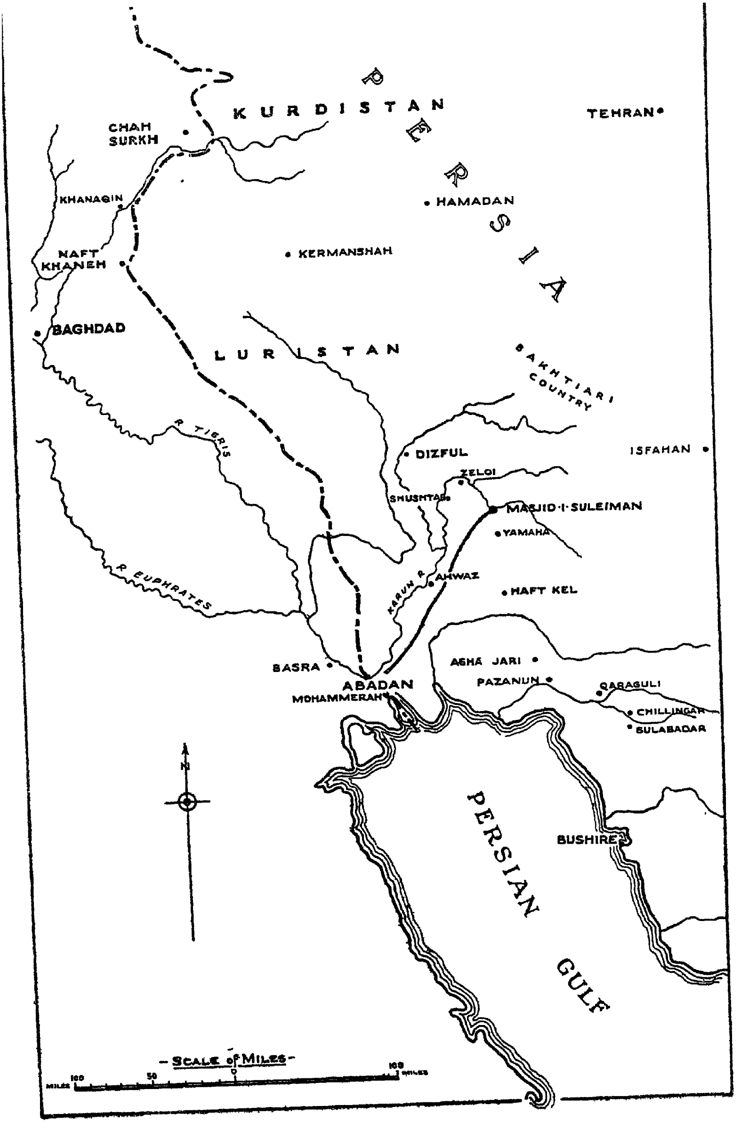

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IN A PERSIAN OIL FIELD

A Study in Scientific and Industrial Development

BY

J. W. WILLIAMSON, B.Sc.

Barrister-at-Law, of Gray's Inn
Secretary of the British Scientific Instrument Research Association

With a Prefatory Letter from
The Rt. Hon. the EARL OF BALFOUR
K.G., O.M., F.R.S.

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Prefatory Letter from Lord Balfour to Sir John Cadman, the Chairman of the Anglo-Persian Oil Company.

WHITTINGEHAME HOUSE,
HADDINGTON,
SCOTLAND.

September 26th, 1927.

DEAR SIR JOHN CADMAN,

I am very grateful to you for sending me Mr. Williamson's admirable work, "In a Persian Oil Field." You tell me that this is due in part to what I said at the Mansion House in one of the many speeches which I have made upon the application of science to industry. If this is so, I am indeed to be congratulated; and I am sure that those who share my views on this subject will derive, as I have derived, much satisfaction from reading this lucid exposition of a particular case in which science and industry have successfully co-operated.

Yours sincerely,
BALFOUR.

INTRODUCTION

THE sub-title proclaims this book to be a study in scientific and industrial development. So many publications dealing with science in industry have been issued in recent years that, perhaps, some explanation, if not excuse, is desirable for this addition to the number. Most of the contributions to the subject have approached the question on general lines and reinforced the argument by illustrative examples drawn from several selected industries or from numerous industrial firms. The method adopted in the following study is the reverse of this process ; it is to describe, as a concrete illustration of the applications of science to industrial development, the work of one corporation only, the Anglo-Persian Oil Company, in one industry, the oil industry, and to treat the subject in such a way, it is hoped, as to lead to an appreciation of what is implied when we speak of the industrial applications of science.

If practice is better than precept, it may be that the study of how an individual corporation has assimilated scientific knowledge and methods into its

sonal reasons, was necessarily brief, but the writer had an opportunity during a period of nearly a month of visiting the greater part of the active area of the Company's operations in Persia.

It should be understood that what follows is not intended to be a critical review, from a scientific standpoint, of the work of the Company. It is, to speak frankly, an appreciation but, the writer hopes and believes, a judicious appreciation.

Nor is it to be taken, in any way, as a technical summary of the operations involved in finding, getting and refining crude oil. The numerous text books published on these subjects contain full information on these points, nor does the writer claim any particular competence to add to their number. What he went out to see was how far the work of the Anglo-Persian Oil Company in Persia was an example of the application of science to industry, interpreting the word science in its widest sense, so as to include the methods of dealing, not only with the raw material obtainable from the crust of the earth, but also with the human and sociological factors necessarily involved whenever and wherever large scale production is carried on.

The genesis of this book was inspired, to a great extent, by some observations made by Lord Balfour

on the general subject of the application of science to industry. The writer records gratefully his indebtedness to Lord Balfour for the privilege of being permitted to include, by way of preface, the letter from his Lordship to Sir John Cadman that precedes this introduction.

The writer expresses also his thanks to Sir John Cadman, the Chairman of the Anglo-Persian Oil Company, and to many members of the Company's staff for the valuable and willing help given to him. It would take up too much space to name all those to whom he is so indebted, but the writer hopes he will be absolved from the fault of making any invidious distinction if he acknowledges especially his obligations to Mr. J. Jameson, Dr. M. Y. Young and Mr. H. Y. V. Jackson, with whom he was brought into frequent contact in Persia. To the Council of the British Scientific Instrument Research Association also the writer expresses his cordial thanks for the leave of absence generously granted to him to enable him to visit Persia.

J. W. Williamson.

Gray's Inn, London.
September, 1927.

CONTENTS

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LIST OF ILLUSTRATIONS

PART I

THE SCIENCE

B

CHAPTER I

THE PERSIAN OIL FIELD

IT may be well at the outset to describe briefly the area covered by the Anglo-Persian Oil Company's present active operations in Persia and in the contiguous transferred territories in Iraq. This area extends generally in a north-west, south-east direction, from Naft Khana and Khanaqin, in north-east Iraq, to Gach Qaraguli, in south-west Persia, a total distance in this direction of about 400 miles. From north to south it stretches for 150 miles or so from Godar Landar on the river Karun to the island of Abadan at the head of the Persian Gulf. The principal oil-field—the original and famous Maidan i Naftun field and its extensions—lies in the northern part of this area, in the district having Masjid i Suleiman (Solomon's Temple) for its centre, some thirty-five miles north-east of the ancient Persian city of Shushtar, the oil being found directly beneath the foothills that give on to the high range of the Bakhtiari Mountains, which form the great barrier between the desert plains to the south and south-west and the great

central plateau of Persia. Between the extreme well in the north-west of this Masjid i Suleiman oil-field and the extreme well in the south-east is a distance of about fifteen miles.

At Abadan there is a great refinery for the treatment of the crude oil from this field and also a modern port at which the tankers take in crude oil for shipment to the Company's new refinery at Skewen, Llandarcy, S. Wales, and refined products for other destinations.

Another important oil field has been opened and is in course of rapid development at Naft Khana in Iraq, some 100 miles north-east of Baghdad; and a refinery to supply local requirements has been erected to deal with the crude oil from this field, about twenty-five miles north-west of it, on the river Alwand, near Khanaqin, which is the head of a railway from Baghdad and also on the caravan route to Teheran. Test borings are also being carried out at various places in South Persia.

That, roughly, is the area of the present active operations of the Anglo-Persian Oil Company in the Middle East. The area covered by the concession from the Persian Government is, of course, much greater. It includes practically all Persia except certain provinces in the north and north-west around the

Caspian Sea, and covers no less than 500,000 square miles.

The visitor who desires to reach "Field"—the name given "for short" to the main oil field having Masjid i Suleiman for its centre—from Abadan proceeds by boat up the Shatt el Arab and then up the river Karun, which winds and twists through the desert, as far as Dar i Khazineh, some 170 miles by river from Abadan. At Ahwaz, about ninety miles by road from Abadan, the navigation of the Karun river is interrupted by a series of rapids and here the Anglo-Persian Oil Company has important workshops, stores and transhipment equipment, for transferring, by rail and road, materials and persons above and below the rapids. From Dar i Khazineh a railway or a road, both constructed by the Company, take the visitor through the foothills and the gorge of the river Tembi to Fields, distant about thirty-five miles.

The desert between Abadan and Dar i Khazineh is an excellent natural road for mechanical transport, although, after heavy rains in the winter, it becomes impassable. The introduction of motor cars has reduced the time taken for the journey from Abadan to Fields from five days to eight hours. The river Karun is, however, with modern steamers and barges,

still the most economical means of transporting heavy materials.

The work of the Anglo-Persian Oil Company is, of course, to find oil, to get the oil when found, to refine it and to distribute the refined products. It may simplify the task of showing to what extent and in what manner science has been and is being applied to the operations of the Company if we take, roughly, this order of presentment and then proceed to describe those social, educational and other developments which have grown with the growth of the Company's industrial operations, and, as will be seen, have been assimilated into the organic whole of the Company's corporate activities.

CHAPTER II

FINDING THE OIL

IN most countries where oil has been found indications of the presence of oil-bearing strata are generally, though not always, known before the geologist is called in to play his scientific part. Leakages of gas or of oil or of both—technically known as " seepages " —are often, and perhaps usually, matters of native knowledge and past history. The seepages may be misleading to the oil prospector. They may be evidence not that oil in any quantity is now there, but that it has been there, the seepage being merely the residue of a once existing great store. Structural indications of the character and conformation of the strata forming the earth's crust often give to the experienced geologist better evidence of the probable presence of oil-bearing strata.

The problem of finding the oil is, therefore, essentially a scientific problem. It is not merely a matter of noticing some oil or gas oozing from the earth, or oil floating on the surface of some stream, and then drill-

ing a well somewhere near by in the hope of striking a hidden oil field. When it is realised that to sink a well may cost upwards of £20,000 it will be understood that "wild cat" drilling is uneconomic. A series of scientific investigations has to be made, and the resu ts have to be co-ordinated and correlated before any prudent and reasonable decision can be taken to sink a test well at any spot. Let us glance at these preliminary scientific investigations as they are conducted by the Anglo-Persian Oil Company.

GEOLOGICAL

At Mohammerah on the river Karun, near where that river flows into the Shatt el Arab, the Company has its geological headquarters. There is an institute furnished with a complete geological and cartographical equipment and containing also a museum of geological specimens obtained from the various areas of the Company's operations. These specimens, it may be noted by the way, form a valuable and available record for, and contribution to, the science of geology, apart from any applications to the oil industry. A scientific staff of geologists, cartographers, draughtsmen and map printers constitute the personnel under the direction of the chief geologist.

From here the geologists and the surveyors are sent out, as required, completely equipped with the scientific instruments, implements and even camping outfit needed, to the area to be explored.

The work of the geologists and surveyors is frequently an arduous business in Persia. Many of the areas to be explored have never before been visited by Europeans, no maps exist, food and water are scarce or not to be found, and not only roads, but even mule tracks, are non-existent. Apart from the delicate task of getting on good relations with the local inhabitants, the supply of the food and water needed, the transport of the materials and equipment, and the maintenance of communications in such remote areas constitute problems of great difficulty.

The first business of the geologist who is called in to examine a suspected field is to make a geological reconnaisance of the area. A rough topographical survey of the surface is made simultaneously, if an adequate topographical map does not exist. Next a more detailed geological survey is carried out and a geological map is drawn on a large scale, say, three or six inches to the mile, the scale depending on the complication or simplicity of the strata encountered.

So far we are dealing only with the geology of the surface, though much information of the underlying

strata may be given by, and deduced from, the "outcrops" in, or not too distant from, the area under examination—i.e., from those places where the underlying strata have turned so as to come to the surface or have been otherwise exposed, as, for example, in cliffs, gorges or river beds. The various formations so exposed are identified, their thicknesses measured and their direction and the direction of any folds there may be—what is called the "strike"—carefully noted. From these data information is obtained as to the character and structure of the underlying strata—the sub-surface geology. This information is supplemented and confirmed or corrected later, as we shall see, from the direct evidence obtained in the process of drilling.

The task of the geologist in the Masjid i Suleiman district was extremely difficult by reason of the character of the earth's crust here. During the period of the folding of the earth's crust in this region, not only were the strata twisted and crumpled in an extraordinary way, but great quantities of certain of the more plastic underlying strata were squeezed out from between other more rigid strata and thrust forward so as to cover younger beds, with the consequence that the deductions as to the run and character of the underlying strata, which may normally be

A GENERAL VIEW OF THE MASJID I SULEIMAN OIL FIELDS

drawn from outcrops, were utterly untrustworthy here. It was geological chaos.

As the visitor approaches "Fields" by rail from Dar i Khazineh he climbs gradually through foothills which are mainly masses of smaller or larger detached mounds; then through a gorge cut by the river Tembi through a mass of rock, mainly gypsum, the local name of which is "gach" and which is the plastic stratum referred to as having been squeezed out; and eventually he comes to a view of hills like nothing so much as the innumerable ridges, peaks and hillocks, closely packed and apparently all higgledy piggledy, that a child could make by crushing tightly a mass of tissue paper in its hands. It is in this terrain and below such a surface jumble that an oil field has been discovered and tapped which not only may well turn out to be the most productive and extensive oil field in the world, but is unique in the simplicity and "oneness" of its structural character.

It may be as well, perhaps, to describe here and now, in the barest outline, the character of this oil field. The oil is found at depths of from 1,000 to 5,000 feet or so below the surface, in the main limestone strata which outcrop in the great hog's back of Asmari Mountain, some seventeen miles away to the south-east. Above this oil-bearing limestone rock is, by fortunate cir-

cumstance, a hard " cap rock " of anhydrite and above this again are other strata—shales, sandstones and conglomerates—forming what the geologists call the lower, middle and upper Fars formations.

There has been discussion as to how the oil is held in the limestone. Is it contained simply by the porosity of the limestone, or is it in larger cavities in the rock? In the geological department at Fields experimental investigations have been made as to the validity of the porosity theory. All the evidence acquired goes to show that the crude oil occurs, mainly if not wholly, in cracks, fissures and canals within the main limestone, and that the interconnections between these breaks in the continuity of the limestone are such that the oil reservoir in this field is one.

Moreover, the underground structure has a corresponding simplicity. The limestone runs, as is frequent with many strata, in longitudinal wavy folds forming synclines and anti-clines, and some of these folds are also folded laterally in a direction at right angles to the longitudinal folds, the effect being to produce a domed structure. In the present producing areas of the Masjid i Suleiman field the limestone can be regarded as consisting essentially of two main domes—the Naftun Dome and the Naftak Dome—the rims of which touch for a considerable distance, covering the

one common reservoir of oil. There are also indications of other domes, notably one called the Golak Dome. Within these domes gas from the oil has accumulated in the past and rises continuously, as oil is withdrawn, to the roofs of the domes and the pressure due to this accumulated gas is the most important factor in the recovery of the oil. A visitor standing a little north-west of the ruins of the Masjid i Suleiman, that ancient Zoroastrian fire temple, and looking generally north-west can see clearly in the broad lines of the strata exposed around him an unmistakable indication of the lateral folding that has given this domed structure to the rocks beneath.

It will be realised, in view of what has been said as to the inherent geological difficulties in this field, that the full knowledge now obtained of the subsurface structure has come from many lines of investigation and especially from the direct evidence supplied by each new well drilled. The geological information gleaned from the Masjid i Suleiman field has been applied scientifically to the work done in test areas in other parts of Persia, and it has been useful in showing ways in which the usual geological methods and procedure can be suitably modified to meet Persian conditions.

GEO-PHYSICAL

Simultaneously with the geological investigations in any chosen area, or maybe at a later stage, depending on the surface character of the district, more particularly on the presence or absence of mountain masses, the Eötvös Torsion Balance may be called on to give collateral or supplementary evidence. It is essentially an instrument for determining the variation of the gravitational force of the earth at different points of the earth's surface. The balance in its first form was devised nearly forty years ago by Baron Eötvös, professor of Physics at Budapest. Professor Hugo de Böckh, an eminent Hungarian scientist, was the first to draw attention to the geological significance of the varied readings obtained by the Torsion Balance and to the possibilities of the instrument in elucidating sub-surface structure.

The instrument is extremely delicate and sensitive in use, requiring the finest and most careful adjustment, and elaborate precautions have to be taken to exclude effects due to vibration and changes in temperature, for example. Corrections have also to be made in its indications to allow for the influence of mountains, hills or even undulations in the neighbourhood. For this reason the use of the torsion

balance is usually confined to more or less level ground where beds are not exposed and where the geological information is, therefore, scanty, as, for example, in the desert.

The instrument does not and cannot indicate directly the presence or absence of oil below the surface; it merely shows, as a traverse of its indications is taken, how the gravitational force of the earth varies from point to point. From its indications, duly corrected and evaluated by complicated calculations, deductions—probable rather than certain—may be made as to some of the characters of the strata beneath the surface and of their direction and inclination. Such information, correlated with that obtained by the geologist and also with other information obtained in ways presently to be described, is of value to the prospector who is seeking oil. The Anglo-Persian Oil Company is making extended experimental use of this torsion balance and the experience gained is brought under contribution, not only to the main purpose of finding oil but also to the development of the theory and practical applications of the balance. There is a small corps of trained scientists—the geophysicists—enthusiastically pursuing this two-fold purpose.

This gravimetric method of oil finding, by means of

the torsion balance, is, however, only one of the many geophysical methods which the Company is employing or rigorously investigating. These other applications of the growing science of geophysics may be classified conveniently as follows :—electrical methods, depending upon measurements of the electrical conductivity of the rocks forming the crust of the earth; magnetic methods, depending upon measurements of their magnetic permeability (a term perhaps sufficiently self explanatory to the general reader); and seismic methods, depending upon measurements of the elasticity of the rocks. Only the barest indication of some of the characters of these investigations, and of the broad scientific principles involved, can be given here, if we are to keep faith with the general reader and avoid trespassing too far into the technical domain.

ELECTRICAL METHODS

The reader can readily understand, in a general way, that the different strata forming the earth's crust will conduct an electric current differently, some rock formations offering a greater resistance to the passage of the current than do others. Of the electrical prospecting operations we may try to give an outline of the potential methods.

In the potential methods a current of electricity is made to flow through the earth between two plates, or electrodes, sunk into the soil, and distant from each other a mile or more. The current is brought to these electrodes by insulated wires and may be direct or alternating current.

Whenever an electric current is flowing between two points in a large heterogeneous mass of conducting material, the current distributes itself in a manner which is largely determined by the conducting properties of the different portions of the mass. This distribution of the current can be explored by measuring the electrical pressure, or electric potential, as it is termed, at a series of chosen points in the conducting mass. In the case we are considering the conducting mass is, of course, that part of the earth through which the current flows. From the observations of potential a map is constructed on which are traced the equipotential lines, i.e., the lines that go through all points at the same electric potential, just as the contour-lines of a topographical map go through all points that are at the same height. We thus get a potential map of the region under investigation which is similar in principle to a topographical map.

From the equipotential lines may also be derived the equipotential surfaces, i.e., those surfaces each

one of which has every point in it at the same electric potential; just as, for example, the surface of a levelled billiard table has all points in it at the same height from the ground level. The application of such a potential map to the problem of oil-finding depends upon the following considerations:

When the ground is homogeneous the distribution of the potential surfaces can be calculated. Let us call this the ideal distribution. When, however, the ground contains rocks or minerals of different electrical conductivity, there is a modification in the ideal distribution of the potential surfaces, and this is shown on the potential map. For example, a conducting mass acts as if it pushed the equipotential surfaces outwards, towards the sides of the mass; a non-conducting mass, on the other hand, tends to pull the equipotential surfaces towards itself. If, then, we may assume, as we may fairly do, that an oil-saturated sand, or other oil-bearing formation, is a bad conductor, it will modify the distribution of the equipotential surfaces in the manner just indicated for a non-conducting mass.

Furthermore, it may be pointed out, when an equipotential surface passes from one area to another area of different conductivity it is refracted or bent at the

frontier separating the two areas, just as a ray of light is refracted on passing from air to glass, or from air to water, for example.

Suppose, then, that an oil sand, or other oil-bearing formation, is suspected to be at some depth below the surface. If the overlying beds are horizontal and there are no seepages, the only method of proving the suspicion is normally to drill down, which, as we have seen, is an expensive process. A knowledge of the equipotential surfaces, however, might help to solve the problem, for the overlying beds may be considered to be relatively good conductors, compared with the oil sand beneath. Where the equipotentiaj surfaces pass from the strata above into the first oil sand, therefore, they will be refracted or bent. In this way the thickness of these superincumbent strata can be measured and this gives the depth at which the non-conducting mass, say, the oil reservoir, is situated.

By this method Professor Schlumberger has observed, in Normandy, the strike of steeply inclined Palæozoic strata under overlying flat beds of Jurassic formation, of from 200 to 300 feet in thickness.

This potential method of electrical prospecting, it should be added, has passed the experimental stage. It has the advantage of being cheap, the apparatus is simple, the technique is straightforward and the time

taken is not extravagant. For example, an area of about ten square miles can be electrically surveyed by this method in about a month.

There are many other electrical methods, of which some may be merely mentioned. In one method, electrical impulses are set up in the circuit which are sufficiently frequent to produce a note in telephones suitably connected. Changes in the sub-surface structure or the presence of a water saturated sand, for example, causes a change in the note heard in the telephones. Zones of silence are said to occur over mineral bodies.

Another method employs Hertzian or "wireless" waves. These waves are able to travel through dielectrics, i.e., non-conductors, whilst they are absorbed or reflected by conducting masses. To take an illustration, if a suspected mass be situated in a mountain, then by directing the radio waves through the mountain, and studying the conditions of reception on the other side, some idea of the location of the mass may be obtained, for if it be conducting it deflects the waves, leaving as it were a shadow of poor reception in its wake. Similarly, it is possible that a petroleum reservoir, being a better dielectric (i.e. a worse conductor) than the surrounding water-saturated rocks, would aid the passage of radio waves.

These and other electrical methods, and even radio-active phenomena, are being investigated by the scientific staff of the Anglo-Persian Oil Company, systematically and comprehensively, with a view to widening the area of scientific attack on the fundamental, initial problem of oil finding.

MAGNETIC METHODS

With regard to the magnetic methods employed, the main object of the Company's work hitherto has been to explore the practical possibilities of these methods for the purpose of oil prospecting. A magnetic survey has been carried out over a portion of the known oil zone at Masjid i Suleiman, with a view to ascertaining whether any marked features of the magnetic observations could be regarded as significant characteristics of the oil zone. The reader knows, in a general way, that the earth behaves as a magnet and that the magnetic force exerted by the earth on a suspended steel magnet, for example, varies at different points of the earth's surface. The measurement of these variations is of great practical importance, not only in navigation but also in many scientific observations. It is sufficient to say here that the careful magnetic survey of the Masjid i Suleiman oil zone

showed broadly that outside the oil zone there was an undisturbed area whereas within the oil zone there were marked magnetic irregularities. The investigations by the geo-physicists of the Company into these magnetic methods are as yet in the early stages of development, but it may fairly be said that they promise to yield results of practical significance.

SEISMIC METHODS

Lastly, to conclude this brief survey of the geophysical work of the Company, an indication must be given of the siesmological research being undertaken. Here again we are dealing with matters in the initial, exploratory stages.

It may be said that hitherto the science of seismology has been confined, for the most part, to recording and measuring the earth tremors caused by earthquakes, and to deducing from the measurements the location of the original disturbance. The argument for the application of seismic methods to oil prospecting runs somewhat as follows.

Oil and bitumen are highly compressible, much more so than any other rocks, so that seismic waves (i.e. earth tremors) going through an oil saturated rock should show a distinct change in the speed of

propagation of both the longitudinal and the transverse wave caused by the seismic disturbance. If subsurface structures have been determined by the geological or geophysical methods previously described and the conclusion has been reached that oil may be present, then, if it could be proved by a seismic method that there is a very compressible substance present, the possibility of striking oil or gas would become a probability and almost a certainty.

A distinguished Irish seismologist has taken records near Dublin, extending over several years, which clearly show, apart from occasional earthquake tremors, the existence of a continuous tremor during the whole period under observation. On calculation it was found that the periodicity of this tremor coincided exactly with the periodicity of the Atlantic rollers breaking on the West of Ireland coast. That the tremor might well be related to the Atlantic rollers is further indicated when it is noted that the amplitudes, as well as the wave lengths, of the tremor were of greater magnitude on stormy days than in fine weather, thus corresponding to the changes of sea conditions.

There are other seismic movements in the earth besides those caused by the surf and, indeed, it is reasonable to suppose that, from one cause and

another, the earth can be considered to be in a state of perpetual tremor almost everywhere. The problem is to measure these tremors and to see whether the observations will throw light on hidden underground structure. We cannot indicate the experimental methods here, except to say that they involve the use of instruments of the highest precision and sensitivity, One instrument, the Ultra Micrometer, for example. is capable of registering a movement of one-eighth of a millionth of a centimetre or one-twentieth of a millionth of an inch.

. . . .

It was said at the beginning of this chapter that the problem of oil finding was essentially a scientific problem. The reader will have realised the comprehensive and the intensive character of the methods—geological and geophysical—by which the Anglo-Persian Oil Company is seeking to put this problem on a sound and broad scientific basis. They call not only for the highest scientific knowledge and skill in the individual worker but also for a correspondingly high degree of staff work to ensure the continuous co-operation and co-ordination of the scientific workers in their common attack on this fundamental problem. The main purpose of these geological and geophysical

investigations, it should be noted, is to ascertain the limits of the various methods for elucidating geological sub-structure, so as to facilitate the selection of the method most appropriate to the peculiar conditions of the particular area under exploration.

CHAPTER III

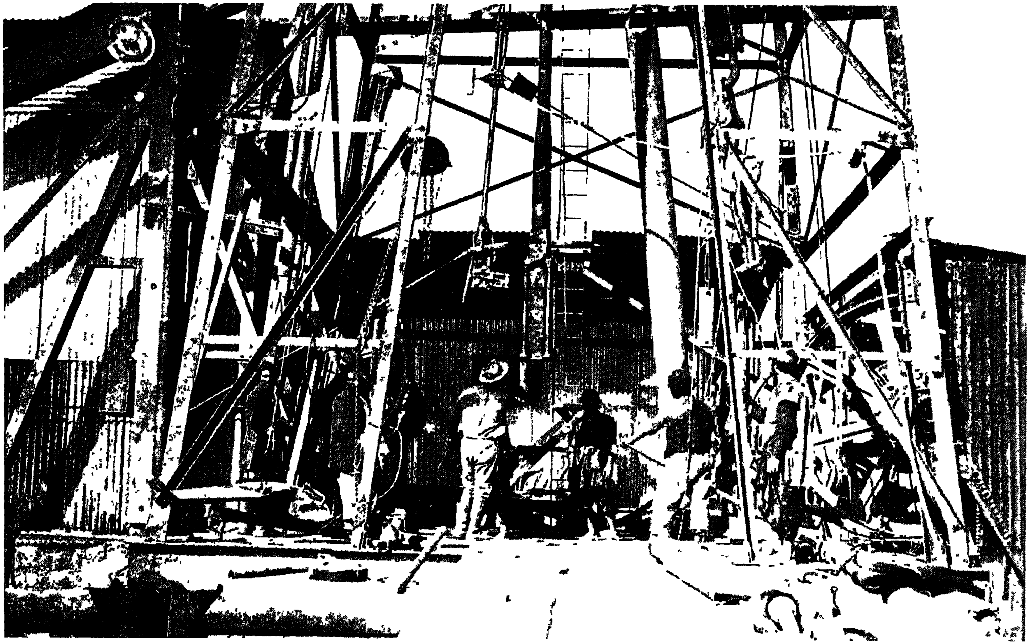
DRILLING THE WELL

FROM the outset the question where to start boring for oil is essentially a scientific problem to be solved by the application of scientific knowledge and methods. We shall see that every subsequent step, from the drilling of the well to the delivery of the refined oil, in the condition and of the character required by the consumer, calls also for the application, in greater measure at some stages, in less measure at others, of scientific knowledge and methods.

Let us now suppose that, from the investigations described, a likely spot has been found for the sinking of a well. The drilling problem is essentially an engineering problem and both engineering in general and the engineering of well drilling in particular have long been developed to a high degree of efficiency. The drilling practice adopted by the Anglo-Persian Oil Company is, therefore, naturally standard practice and it will be sufficient to describe the methods in outline only.

Two systems of drilling are employed—the cable-tool or percussion system and the rotary system. In the first a heavy cutting bit of hard steel at the end of a wire cable is alternately raised and lowered, by appropriate machinery, so as to produce a succession of blows whereby the hole is literally pounded out, the crushed strata being baled out from time to time. In the rotary system a rigid stem of steel pipe rotates, by the help of machinery, a special type of cutting-bit, which bores through the strata as a gimlet bores through wood. Through the drill pipe a mud flush is pumped down under hydraulic pressure. This stream of liquid mud serves to lubricate the process of drilling, to drive up the cuttings out of the hole and at the same time to " mud up " the formations encountered to prevent them caving. Hence this system is especially adaptable to unconsolidated strata, such as caving sands or silts. The cable-tool system is better suited to harder rocks.

The chief advantage of the rotary system is the rapidity with which a well can be drilled. As much as 450 feet per day has been made under exceptionally good conditions, which is a far greater depth than is possible with the cable-tool in normal circumstances. Other advantages of the rotary system are that if high gas and oil pressures are encountered, they are



THE DERRICK FLOOR OF A STANDARD TYPE DRILLING RIG. SHOWING THE HEAVY CABLE BIT WHICH POUNDS ITS WAY THROUGH THE ROCK

more easily controlled; less casing is required for the lining of the well; it is less costly to employ than cable tools and it is more universally adaptable to the normal conditions of modern oil-field development. It has, however, two inherent disadvantages, one, the tendency through "mudding" for the driller in charge to miss oil shows, and the other, the difficulty of obtaining uncontaminated samples of the strata bored through, to enable the geologist to elucidate the sub-surface geological data. The first disadvantage can be minimised, if not avoided, by the skill of the driller. The second has been successfully overcome by the introduction and use of the core-barrel, a device by which satisfactory samples can be regularly obtained.

In the Masjid i Suleiman field, however, it has been found that wells up to 3,000 feet deep are more economically drilled by cable tools; for wells of a greater depth than this the rotary-drill is more advantageously employed.

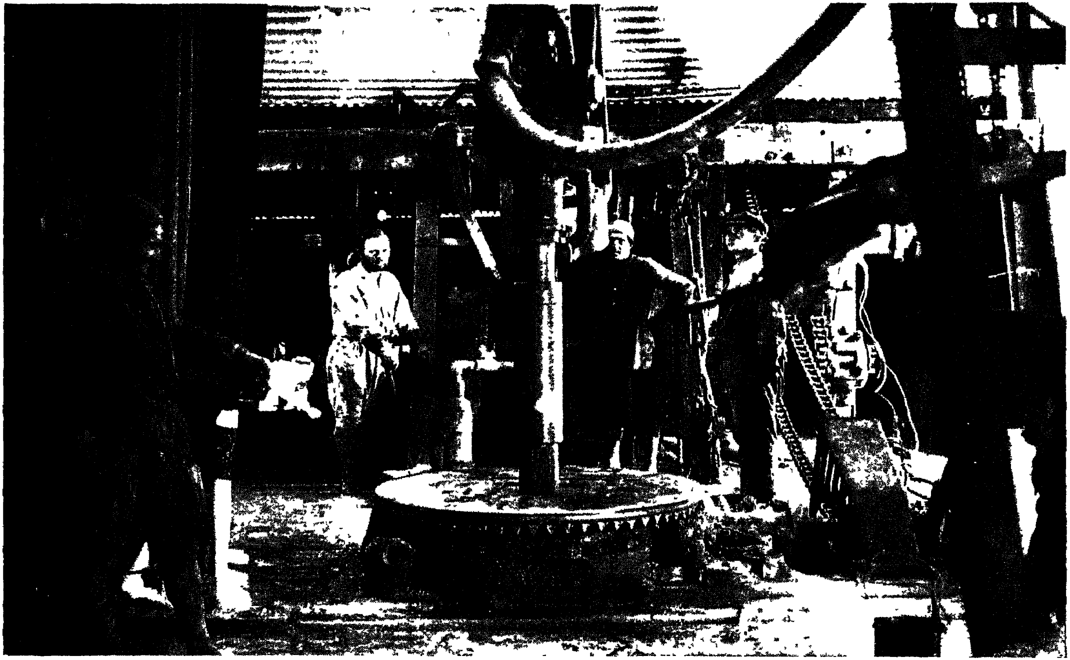
When the writer was at Fields, a well was in process of being drilled by the rotary method, for geological information and not for production, which had then reached a depth of 5,000 feet. It was fascinating to watch this rotary drill, roughly a mile long, being turned apparently as easily as one turns a gimlet. This

well, it may interest the reader to know, at the end of May, 1927, had reached a depth of 5,809 feet and the casing lining the well ceased at a depth of 2,421 feet, no other casing being required below this.

PETROGRAPHY OF DRILL CUTTINGS

Daily reports of the progress made at each well, of the depth reached, of the strata met with and of other significant features, are made by each driller in charge and copies of these reports are studied by the geologists. Moreover, at intervals of five feet—or oftener if new formations be encountered—samples of borings are taken and sent to the geological department for examination and identification. Here they are washed, dried, examined by the eye and by the microscope and, where it is deemed desirable or necessary, are subjected to chemical analysis.

For example, the cap rock of anhydrite, which covers the oil-bearing limestone, shows under the microscope a peculiar radial structure. If there be any doubt in a given case whether it is the cap rock that has been reached, the microscopic examination of a specimen of the boring reveals the presence or indicates the absence of this radial structure and thus usually resolves the doubt. Similarly, microscopic



TURN TABLE AND DRILL STEM OF A ROTARY DRILLING RIG AT MASJID I SULEIMAN

examination helps to determine whether any limestone met with in drilling is the mother-rock which outcrops in Asmari mountain. If any water be encountered by the driller samples of it are sent to the chemical laboratories for determinations of its density and composition and from the knowledge thus acquired valuable information can be obtained of any interconnections there may be between distant borings. It is worth notice that all the specimens of borings are carefully kept for reference and are available as contributions to the general science of geology.

There is thus a steady flow into the geological department of information and samples from all the wells being drilled as they are being drilled. From the data thus acquired, duly co-ordinated and correlated, a detailed knowledge is obtained of the sub-surface structure over a wide area. Since some two hundred wells have been drilled in the Masjid i Suleiman field, it will be understood that a thorough and extensive knowledge of the sub-surface geology has now been acquired. Indeed, the "geological chaos," to which reference was made, has now been, in the expressive phrase of the geologists, all "taped out." At Fields, at the geological headquarters at Mohammerah and also in the London offices of the Anglo-Persian Oil Company, there are not only large scale maps but also

solid models constructed to scale showing the contours of the oil-bearing limestone and the position of each well.

It should be understood that as the well is drilled it is also lined by steel casing. When the driller is nearing the main limestone where the oil is expected, precautions have to be taken against any sudden rush of oil to the detriment of the drillers and the rig. A long cyclindrical steel vessel, called a container, is fastened to the top of the well casing and the cable works, enclosed, through this. A valve is also introduced near the top of the well pipe and controlled by a distant handle, so that in emergency it may be turned off without grave risk to the operator. There is something of a dramatic thrill, in approaching a well, to observe that the "container" is affixed and to read the notice: "No smoking. Drilling in Main Limestone."

By such devices and precautions a well with a production of as much as 3,000 tons of oil per day can be brought in without any loss of oil, the derrick floor being kept clear of any waste oil. Indeed, the amazing feature to one who visits the Masjid i Suleiman oil field for the first time is the absence of any sight of the crude oil, except for the seepages to be noted here and there in the area. Not until the writer reached the refinery at Abadan, 130 miles away from the oil field,

did he see the crude oil which was being drawn from Fields at the rate of some 4,000,000 gallons per day. If one compares this state of things with, for example, pictures of the oil fields of Russia, in Mr. A. Beeby Thompson's elaborate book on the Russian Petroleum Industry, where derricks and rigs are shown drenched in the spouting oil and gas, and where lakes of waste oil surround them, the scientific achievement of the Anglo-Persian Oil Company in avoiding waste and keeping Fields clean of oil can be better appreciated.

CHAPTER IV

STUDY OF PRESSURES AND LEVELS

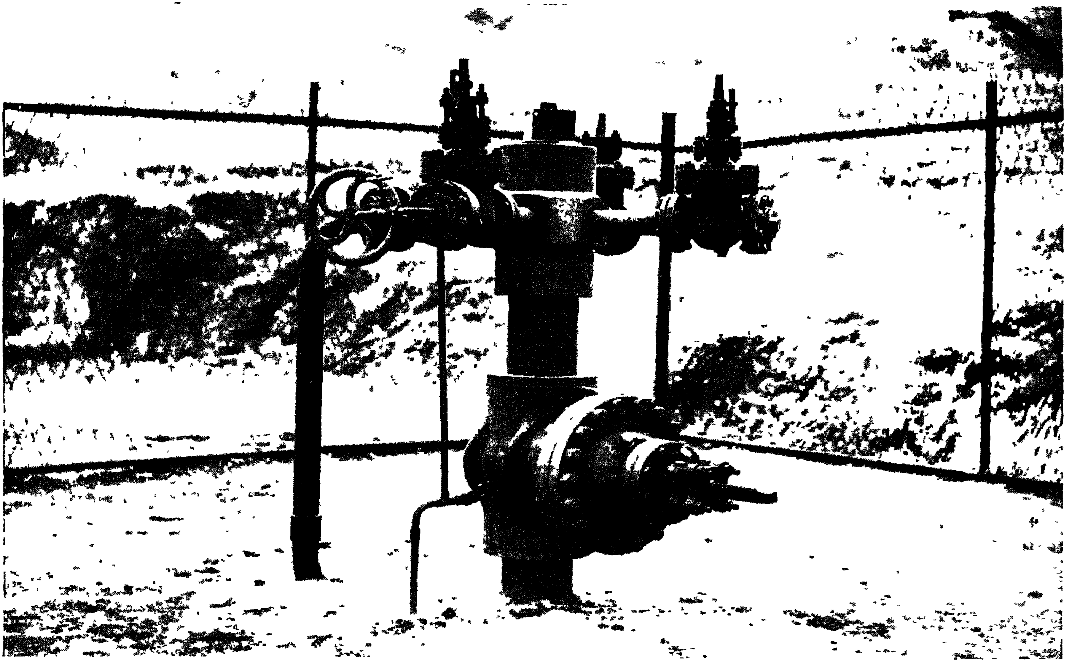
DRAWING THE OIL

When an oil reservoir is reached the oil may rise in the well pipe and flow under its natural pressure. But there may be difficulties due to excessive flow; on the other hand the oil may have been struck at such a great depth that the natural pressure to which it is subjected is insufficient to start it flowing. Both these difficulties call for the ingenuity of the engineer. Excessive flow has to be checked by appropriate and sufficiently robust well-head fittings. To get the oil to flow from great depths, frequently gas is forced down the well pipe under pressure, so as to "aerate" the oil, "to make it alive," as the phrase goes. When the pressure is released the mixture of oil and gas usually rises and flows just as soda water gushes from a syphon when the pressure is released. In the Persian oil field there have been hitherto few, if any, difficulties in getting the oil to flow: such difficulties as have been encountered and successfully overcome have been due to high pressures and excessive flow.

We will now suppose that a well has been drilled in and that the oil is flowing under proper control into the pipe line leading to the tanks where, as will be seen, the crude oil is first stored. The well-head fittings include, besides valves for regulating or stopping the flow, pressure gauges for the accurate measurement of the pressures developed at this point. A whole series of scientific investigations into the measurement and implications of these pressures is now undertaken, investigations which are peculiar, in oil-field development, to the Anglo-Persian Oil Company.

When a well "comes in" the gas which rises with the oil, usually at first in great quantity, is allowed to blow off, and is led away to be burnt, until the well pipe is full of oil to the head. The valve is then closed, things are allowed to settle down, and the pressure recorded by the pressure gauge under these steady conditions is carefully noted. This pressure is termed the *Minimum Closed in Pressure.* The reader who has an elementary knowledge of hydrostatics will realise that this pressure is equal to the hydrostatic pressure on the oil at the bottom of the well less the downward pressure due to the weight of oil in the pipe. The purpose of the measurement of this pressure will be explained later.

The oil is now allowed to flow freely into the pipe



FLOWHEAD OF COMPLETED WELL SHOWING MODERN HIGH PRESSURE FITTINGS

line and the pressure is measured while the well is flowing. This pressure is termed the *Flowing Pressure.* Not only is it dependent on the size and conformation of the well that has been tapped but it varies also with the back pressure set up in the pipe line fed by the well. The reader will understand that the flowing pressure of the water in a water main, for example, must vary with the back pressures set up in the various smaller pipes which are fed by the main. The importance of measuring this flowing pressure is that from it reliable calculations may be made of the production of the well, i.e. the number of gallons of oil per day that the well is yielding. In contrast with most oil fields the individual production of wells in this Persian field remains practically constant.

If a freely flowing well be closed, the pressure developed at the well-head will be greater than the minimum closed in pressure; for when a well is flowing freely not only oil but also gas flows and when such a well is closed in the gas collects in the well-head and casing top. The pressure under these conditions, which is termed the *Maximum Closed in Pressure*, is carefully measured. The reader will appreciate that it is equal to the static pressure at the bottom of the well pipe less two back pressures—the back pressure of the column of oil in the well pipe

due to its weight, and the back pressure of the column of gas above the oil in the pipe. The function of this measurement of the maximum closed in pressure is to determine the highest pressure to which the flow-head fittings will be subjected—obviously important knowledge to the engineer.

Lastly, a fourth pressure is measured. It will be remembered that above the oil in the present producing area of the Masjid i Suleiman field are domes under the roofs of which gas has accumulated and to which it is constantly rising. Whenever a well is sunk directly into the gas dome overlying the oil reservoir, the pressure of the gas at the well head is measured. This is termed the *Dome Gas Pressure.* Its function will be explained almost immediately.

To recapitulate, there are four distinct and significant pressures periodically measured—the minimum closed in pressure, the flowing pressure, the maximum closed in pressure and the dome gas pressure. In order that all these pressures, measured at different wells and at different ground elevations, shall be comparable one with another, the observations taken are corrected and referred to a common datum level, a presumed sea-level known as Scott's datum level, and thus inequalities in the observed pressures (due to some

wells being drilled in from a higher point of the earth's surface than are others) are eliminated.

THE GAS-OIL LEVEL

From the knowledge of the minimum closed in pressure and the dome gas pressure it is possible, by mathematical methods, to determine the gas-oil level, i.e. the level at which the gas in the dome meets the surface of the oil in the reservoir. It would be outside the scope of this essay, which is written for the general reader, to attempt to explain the nature of the mathematics involved. The reader is asked to accept it as fact that reliable determinations can be so calculated.

From the knowledge of the gas-oil level most important conclusions can be drawn, affecting not only the location of new wells, but also the general production policy in the area. It enables decisions to be made as to the location of new wells for production in areas where the contours of the main oil-bearing limestone are known. From it can be deduced with confidence data indicating which wells would, if they were sunk, produce gas only; which wells would, though yielding oil for a time, soon go to gas; and which wells would be likely to have a

long flowing life before going to gas. Incidentally, it may be remarked that the problem of the flowing life of wells is a very interesting scientific problem on which much investigation has been done by the Anglo-Persian Oil Company.

Moreover, and not least important, a knowledge of the gas-oil level, correlated with other data, enables approximate estimates of the total oil reserve to be made.

It will be seen, therefore, that continuous knowledge of the gas-oil level is of great and even vital consequence. In the geological department at Fields are carefully drawn graphs showing the relation between the gas-oil level and the production (i.e. the total quantity of oil withdrawn from below). As oil is withdrawn from below the hydrostatic pressure at the bottom of any given well necessarily falls; the gas within the dome above the oil reservoir expands and hence also the dome gas pressure tends to fall. The object of the graph deduced from the measurements of these pressures is to show the rate at which the gas-oil level is falling as the production is proceeding. It is interesting to note that, owing to measures having been taken to prevent unnecessary loss of dome gas (for example, by "mudding off" gassy wells, that were producing as much as 2,000 tons of oil per day),

the rate at which all Fields pressures and the gas-oil level have been falling has sensibly slowed down within the last two and a half years. The curve showing the relation between the gas-oil level and the production will slope the more steeply the more rapidly the gas-oil level falls with the production. When observations were first systematically taken, the curve had a slight, but obvious, downward slope; it now shows a distinct tendency to approach the horizontal, indicating that the rate of drop of the gas-oil level has become less. That curve is as important in the oil field as is the temperature chart in a fever hospital.

It should be understood that the above description of the scientific work done on the measurement of pressures does not pretend to give a complete picture, even in outline, of all the scientific investigations needed to arrive at definite information as to the gas-oil level, the flowing life of wells or the total reserve. These problems are necessarily related to, and complicated by, such factors as friction, viscosity and the solubility of gas in oil at different temperatures and pressures. A great deal of research work has been and is being prosecuted by the Company's staff on these and other cognate problems.

MIGRATION OF OIL

It may be explained that in areas outside the present producing area test wells are drilled, not primarily for production but in order to secure vital data. These areas are known as Fields extensions. From the above investigations valuable information has been obtained as to the migration of oil. The evidence points to the conclusion that the oil from the extension areas is migrating to the producing areas and that Fields extensions are being satisfactorily drained by wells at present on production. Intercommunication between wells as far apart as ten miles has been proved by study of the pressures. The excellent migration which exists over the whole field, between area and area, musi therefore, be due to the existence of channel connections in the mother limestone rock, of such number and magnitude, that, at the present rate of production in Fields, and at the consequent velocity of migration of the oil, gravity alone is able to overcome the forces of friction, capillarity and surface tension which tend to impede migration.

THE OIL-WATER LEVEL

There is another important level to be determined. In many oil fields the first hint that the reserves of oil are not inexhaustible is given by a rise in the level of

the water, often salt water, usually found beneath the oil. The reader is aware that the oil, being of lighter specific gravity than water and not miscible with it, will float on water. A knowledge of the oil-water level is obviously important as from it the earliest evidence comes as to the rate of exhaustion of the field. It is sufficient to say here that where water has been found beneath the oil horizon in the Persian producing area, careful and systematic measurements over the last three years have shown that the oil-water level is constant and is not rising. This evidence is regarded as so reliable that the possibility of introducing water, pumped from the Karun river, into the salt water below the oil has been suggested as a means of maintaining pressures and thus enabling wells for production to be located higher up the flanks of the limestone domes. In other words, in view of the definite knowledge obtained as to the constancy of the oil-water level and other characteristics of the Masjid i Suleiman field, it is boldly suggested that the underground oil reservoir might be forced up some part of the way instead of having to drill the wells the whole way down to the present level of the oil. To take an analogy, it is as if, there being reason to think it feasible, it were proposed to raise the Kent coal measures nearer to the surface so as to lessen the

depths of the pit shafts needed to be sunk in order to reach the coal. Such an operation is, of course, impossible in the case of solid formations such as the coal seams; it is not inherently impossible or obviously impracticable in the case of a subterranean oil reservoir. Its feasibility depends on the structural character and other features of the particular oil field. Whether the proposal be carried out or not, one hardly knows which to admire the most: the simplicity of the idea; the elaborate and thorough investigations on which the simple conception is based; or the boldness of the engineering operation proposed. The reader will scarcely need to be reminded that it is one of the virtues of thorough-going scientific investigation that it often leads to a bold and simple conception of far reaching economic importance.

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It should be emphasised, what has already been indicated, that all, or nearly all, the scientific work on pressures, just described, is peculiar to the Anglo-Persian Oil Company, and has no comparable counterpart, as far as the writer knows, in the work done in any other oil field in the world. It is true that these co-ordinated scientific investigations are greatly facilitated by the unique simplicity of the structural conditions of that part of the Persian oil field now under

production; and also by the fact that the Company has sole control of the wide area involved. But it would be to miss the real significance of what has been described not to pause and note that the extent and thoroughness of the scientific work done is due mainly to the long and wide view taken by the former Chairman, Lord Greenway, by the Board of Directors of the Company, and, pre-eminently, by the present Chairman, Sir John Cadman, as to the vital necessity of such scientific data and investigation for ensuring efficient production.

CHAPTER V

THE PROBLEM OF THE GAS

WHEN the oil has been brought to the surface and the well has been connected to the pipe line which is to conduct the crude oil to the refinery, there is a series of operations to be considered before we come to the processes of refining.

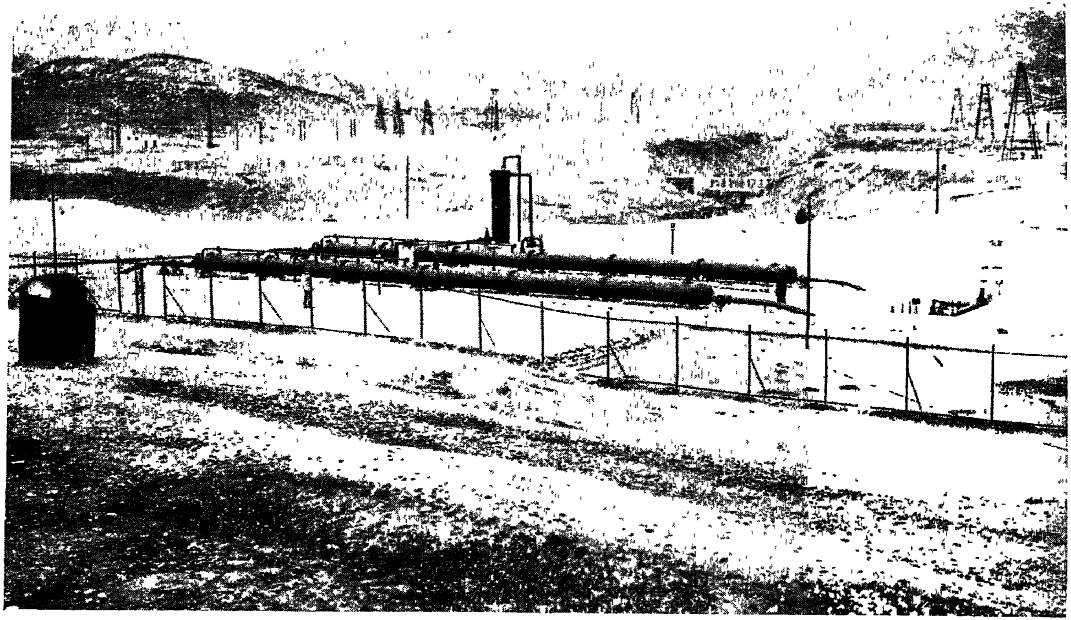
The crude oil, as we have seen, contains a good deal of gas. The immediate problem is, what is to be done with this gas?

In the early history of the Anglo-Persian Oil Company, it will be readily understood, the urgent, economic need, after the oil had been drawn from below, was to get the oil refined and to put the refined products on the market for sale. These early days were not favourable times for pausing at each stage of the process of production to consider whether all had been done that could be done at that stage. The gas problem, therefore, was treated summarily at first, because all energies were necessarily concentrated on the adequate production of refined oil.

The gas could not be allowed to escape freely into

the air. It is injurious to breathe, and, indeed, poisonous. It was, therefore, led away to convenient spots on the hills around and burnt continuously, night and day, in huge flares, the flames rising frequently to a height of one hundred feet. Photographs of Maidan i Naftun in those early days, taken at night, show one of the most wonderful and weird spectacles ever, surely, associated with industrial development. In response to the pathetic plea of one member of the Company's staff the present writer here earns the unique distinction of refraining, though with difficulty, from making a trite reference to Dante's Inferno. But one may be allowed the milder comparison that the blast furnaces of Middlesbrough would have "paled their ineffectual fires" before this field of conflagration. There are still flares in Fields, but the ecstasy of combustion has been somewhat allayed, partly by reason of the "mudding off" of gassy wells, to which reference has been made, and also by methods to be described.

As the early, urgent needs for the production of refined oil were successfully met, attention was directed to the improvement of each step in the series of operations, and the solution of the gas problem has been, and is being, sought along the lines that will now be explained.



GAS SEPARATORS FOR SEPARATING THE GAS FROM THE OIL AS IT FLOWS FROM THE WELL. IN THE OIL-FIELD ON THE MAIDAN

HIGH PRESSURE GAS

The first step taken is to separate a great deal of the gas from the oil. From each well head the pipe line leads immediately to what are called the high pressure separators. It is unnecessary to describe their structural details; it is sufficient for our purpose to say that they are long, horizontal cylindrical vessels of steel, of much greater diameter than the pipe line. Through the lower part of these separators the crude oil flows, on the first stage of its journey to the refinery.

The non-scientific reader may here be informed that whenever oil, or any liquid, is contained in a closed vessel, a certain quantity of gas or vapour from the liquid evaporates into the space above it, until a definite equilibrium between gas and liquid, depending on the temperature and the pressure, is reached. As the oil flows through the lower part of the separators, therefore, gas escapes, or, more accurately, gases escape, from the oil into the upper part of the cylinders. The proportion and the composition of the mixed gas so escaping depend upon the temperature and the pressure. We will ignore the temperature changes, which are not controlled and are relatively unimportant for our argument, and confine our attention to the effects of pressure.

In these high pressure separators the pressure is maintained at approximately 90 lbs. to the square inch. At this pressure the mixed gas that comes off consists mainly of the heavier or less volatile fractions, i.e., the gases of relatively low boiling points. The pressure is chosen so as to secure the evolution of these heavier fractions only. The gas so separated is purified and conducted through mains to the Fields gas supply for industrial and domestic use. It provides the fuel required for the steam boilers at the electric generating station and the pumping station at Tembi, as well as for other steam-raising plant in the various workshops at or within range of Fields. It is also supplied for heating or cooking purposes to the bungalows, houses, offices and bazaars, including the Persian bakery and the Persian baths. There is thus an abundant—indeed, a super-abundant—supply of natural gas to the whole industrial community in or near Fields. What was at first merely a waste product has thus been turned to industrial and domestic use.

The quantity of the gas so utilised is, however, a very small, almost an infinitesimal, fraction of the total gas available, and other steps are being taken to recover more and more of it for industrial purposes.

THE LOW PRESSURE GAS

To resume the story, the crude oil, with the high pressure gas removed, goes its way to great tanks, called the "flow tanks," where the pressure drops to atmospheric pressure. There is still a great deal of gas dissolved in the oil and this gas evaporates and rises to the upper parts of the flow tanks. At this lower pressure the fractions evolved are the lighter and more volatile fractions. We will call this mixed gas the "low pressure gas."

Before considering what is done with this low pressure gas, it may be as well to see the crude oil a little further on its way. From the flow tanks the crude oil, stripped of its high pressure gas and low pressure gas, goes by the pipe line to the great storage tank farm at Fields, whence it is delivered as required to the pumping station at Tembi. From there it is sent on the first stage of its long journey of 130 miles over hill and desert, to the refinery at Abadan.

RECOVERY OF GASOLINE

To return to the low pressure gas in the flow tanks, this gas is now led through pipes to the gas absorption plant, in order that there may be recovered from it the valuable product, light spirit or gasoline. Shortly

PYROLYSIS OR CRACKING

We have not yet, however, come to the end of the gas story. Part of the gas which has passed through the absorption plant and given up its gasoline now goes to another plant, called—it is said, not very happily—the pyrolysis plant, where attempts are being made, and on a semi-large scale have been completely successful, to obtain other products of industrial value. It is outside the scope of this essay, and it would try unduly the reader's patience, to enter upon a technical description of the pyrolysis process, which is also known as "cracking." Broadly speaking, it may be said that the process consists essentially in subjecting the gas under pressure to high temperatures, in order that the lightest fractions of the gas may combine to form valuable liquid products, of which benzole in particular may be mentioned.

When the writer visited Fields the pyrolysis plant was not in full working order on the commercial scale, but was in the intermediate development stage through which all the discoveries of the research department have to pass before they can be translated to full-scale industrial practice. Both at Fields and at the central research laboratories of the Company at Sunbury-on-Thames systematic researches on this

problem have been, and are being, prosecuted and are nearing, if they have not already reached, practical fruition.

The gasoline and the benzole thus obtained do not, however, exhaust the list of useful products recoverable from the waste gas.

OTHER BY-PRODUCTS

In the first place, this gas contains a quantity of hydrogen sulphide (sulphuretted hyrdrogen) which may amount to as much as ten per cent. The hydrogen sulphide itself is a most undesirable constituent, as it has a very unpleasant smell and is highly poisonous. It is for that reason that the high pressure gas is purified before being distributed for domestic and industrial use as fuel. Chemical processes have, however, been devised whereby from the hydrogen sulphide there can be obtained sulphur of an extraordinary degree of purity ; and it will soon be possible thus to rid the gas of a noxious constituent and to provide in commercial quantity, not only pure sulphur, but sulphur compounds such as carbon bisulphide, all of which are of great value and of wide use in medicine, industry and the arts.

Again, any natural gas, if burnt against a cold metal, or other suitable, surface, deposits carbon in the form

of an extremely fine, black soot—"carbon black"—which is much superior to ordinary lampblack as a pigment for the manufacture of printer's ink. Since a thousand cubic feet of gas yield from one to two pounds of carbon black and it is calculated that one pound of carbon black suffices to print 2,250 copies of a sixteen page newspaper, the potentialities of the Fields gas in this direction alone—whether beneficent or deplorable, the reader must decide—are obvious. Carbon black is also largely used in the rubber industry, being incorporated into the rubber in order to give to it the toughness, elasticity and durability sought after by motor tyre manufacturers. Considerable quantities are also used in the manufacture of stove polishes, Chinese and Indian ink, paper and tarpaulins. Already at Fields a small plant has been established and started for the manufacture of this widely useful by-product.

By varying the conditions of carbonising the gas it is also possible to get the carbon in the form, not of soft black soot, but of a very hard, greyish black solid of close grain, which, on account of its exceptional purity, is of great value for electric arc lamps and for other electrical purposes.

Nor does the tale of useful products obtainable from the gas end here. The gas consists of several,

chemically distinct, gases, known generically as hydrocarbons, among which methane and butane may be mentioned. It is possible to separate these constituents by appropriate physical means and to use each one as a raw material for the preparation of other chemical compounds of industrial importance. Thus, by treatment with chlorine, the methane can be converted into chloroform and the butane into butyl chloride and thence into butyl alcohol, which is largely used as a valuable solvent for cellulose lacquer.

Indeed the gas and the whole of the petroleum, taken together, constitute a potential raw material for a stupendous chemical industry, as great as, and possibly greater than, the combined synthetic dye and drug industries which have grown out of the once under-valued coal tar. Ten years ago, to take another example, the research chemists of the Anglo-Persian Oil Company showed that the high explosive, trinitrotoluol (T.N.T.), originally produced from coal tar, could be obtained from Persian, Borneo and other petroleums and large quantities of this explosive were so made during the war.

The laboratory researches and the semi-large scale investigations on the preparation from the gas of all these and other industrial by-products have been

brought to the point, or nearly to the point, when large scale commercial production can begin.

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To summarise this outline of the gas story, as far as it has been told, we have seen that from the gas, which at first was burnt as mere injurious waste, a gaseous fuel, for industrial and domestic use, is obtained, as well as needed by-products, such as gasoline, benzole, carbon black, hard carbon, sulphur and carbon bisulphide. The residue of the gas goes to be burnt in those flares which, for the visitor at least, are still, perhaps, the most fascinating spectacle in Fields. From a daily production of 4,000,000 gallons of oil it is estimated that, despite all that has been done, some 32,000,000 cubic feet of gas per day are so burnt —a stupendous total, enough to supply, for purposes of heat, light and power, the daily needs of Glasgow !

C'est magnifique mais ce n'est pas l'industrie ! It is impossible to believe, therefore, that we have got to the end of the gas story. As long as those flares burn, the scientific soul of the Anglo-Persian Oil Company must be disturbed by the question : "What better use can be found for this gas ?"

In America natural gas has been conducted through mains to large towns, many miles distant from the source of the gas, and there put to wide industrial

PERSIAN OIL FIELDS BY NIGHT

and domestic uses. It has also been compressed in cylinders for distribution. There are no large towns, industrial or otherwise, in Persia which are within reach of Fields and to which the gas could be usefully sent. Shushtar, some thirty-five miles away, is the nearest; but who that has visited that romantic Persian city, with its narrow mud streets, its houses and bazaars of sun-baked mud or brick, in picturesque, or other, disarray, can for a moment think of any useful thing to be done with the gas if it were got there? The only power in Shushtar used for industrial purposes is the abundant water flow of the Karun river which turns the wheels of the ancient mills that yield the stone-ground flour. Everything else in Shushtar that can by any stretch be called industrial, and it is but little, is mere handicraft. And even if some bold adventurer were to embark there on industrial manufacture, relying on the gas from Masjid i Suleiman for power, whither would he send his products?

The problem of those 32,000,000 cubic feet of gas per day remains. It is neither forgotten nor neglected. To discover means of utilising this gas and saving it from total loss to humanity, the writer was assured, is the ultimate goal towards which pure research at Fields is directed.

CHAPTER VI

RESEARCH AT FIELDS

BEFORE we leave Fields for a time—reluctantly, as every visitor leaves Fields—in order to follow the crude oil through the pipe line to the refinery, something more should be said of the scientific work done, and of the equipment and facilities for experimental research provided there.

The chemical research department at Fields is in charge of the chief research chemist (Persia) who is stationed at Fields and who is also a member of the technical staff of the General Manager. He is assisted by a number of British chemists. In accordance with the general policy of the Company to associate Persians more and more with the development of the Company's operations, a number of Persian Mirzas (i.e. Persians who have received a higher school or university education) are being trained at Fields as chemical assistants and show great promise of becoming useful members of the Company's personnel.

The primary function of the Fields chemical labora-

tories, a description of which will follow shortly, is to provide accommodation for research into those problems which are more conveniently investigated on site, such, for example, as depend on ample supplies of raw materials available only in Persia, and which cannot, therefore, be studied at the Company's main Research Station at Sunbury-on-Thames.

A complete liaison has been established ensuring effective co-ordination of all the research work undertaken in Persia and at home. The chief research chemist (Persia) and the chief research chemist at home keep in the closest touch, so that new ideas can be promptly discussed, plans for the investigation of these ideas drafted, and difficulties arising in the course of the research dealt with. In this way needless overlapping or the duplication of investigations is prevented. Moreover, by means of a rotation of staff between the two research stations, the research chemists working at home acquire first-hand acquaintance with the conditions prevailing abroad, while those working in Persia are enabled to keep abreast of the latest developments in apparatus and methods of research. There is thus free diffusion of knowledge and practice between home and Fields and a corresponding, close partnership between the scientific staffs concerned.

When the writer was at Fields, among the more important gas problems then in course of investigation were: the determination of the ratio between oil and gas and of the gasoline content of the gas, under all flowing conditions; the pyrolysis or cracking of the gas for the production of liquid products; and the elucidation of the conditions under which the oil and gas co-exist underground. In addition to these problems investigations were proceeding on the making of carbon black, hard carbon, the recovery of sulphur and the synthesis of new compounds. The development of all these researches has led already to promising results, and, as was inevitable, has opened out new lines of investigation. The synthesis of new compounds, for example, opens on to an almost illimitable field of research.

It should be noted that, besides these wide and varied problems of research, a great deal of routine work is done in the laboratories, involving the regular, chemical analysis or examination of the various materials produced or consumed at Fields. The milk supply, for example, is tested daily and the water supply periodically. Minor investigations are from time to time undertaken to solve difficulties or doubts arising in the course of the Company's operations, for example, on the geological or the engineering side.

New research laboratories of special design, and with modern equipment, have been built recently in an enclosed area of about five acres, situated at Bibian, not far from the centre of Fields. In the construction of these buildings the maintenance of a cool and uniform temperature during the hot summer months, when the thermometer may rise to 120°F. in the shade, has been the first consideration; and the orientation of the main laboratory, the thickness of the walls, the roofing and the ventilation have all been designed to secure this object.

The main building is 132 feet long by 56 feet wide and is constructed of two steel frames and local stone and gypsum. The roof is of corrugated iron covered with carbolastic. The ceiling throughout is of beaver board with ample air space between it and the roof. Wide central passages divide the building into four sections. The half of the building that contains all the laboratories is fitted with inlet ducts which supply cool air from a central duct connected to a water-spray air-cooler placed outside. A small refrigerating plant to keep two rooms at temperatures of 0°C. and 15°C. respectively and to make about one cwt. of ice a day is also installed. The other half of the building contains the workshops (fitted with drilling

machines, lathe and forge), stores, library and typists' room, and is well provided with electric fans.

Besides the main chemical laboratory and the physical laboratory there are rooms for special purposes, such as a dark room for photography, an oil testing room and a room for high pressure work and combustions. All the laboratories are fitted with a supply of purified natural gas, steam, water, compressed air and vacuum. Subsidiary buildings are nearing completion in the grounds for larger scale experimental work, such as the experiments on gas pyrolysis or "cracking." A meteorological station, with a standard screen and instruments, has also been established.

It is true that, as has been well said, the results of research come from men and not from buildings or apparatus. But in the research buildings at Fields the Company has provided for the men a local habitation for research that will bear comparison with the most modern research laboratories at home.

THE STEEPEST SECTION OF PIPE-LINE OVER THE IMAM RAZA

CHAPTER VII

THE PIPE LINE

It will be remembered that we followed the crude oil as far as the Storage Tank Farm whence it is fed by gravity, as required, to the first pumping station at Tembi, some five miles away. We have now to see how this crude oil is transported to the refinery at Abadan.

A few only of the salient features of this stage of the operations will be dealt with here, though the story of the laying of the pipe line in the early days of the Anglo-Persian Oil Company is not the least romantic in its annals. That story has, however, been told before and it lies somewhat outside the purpose of this essay. The distance between Tembi and Abadan along the pipe line is approximately 135 miles. The pipe line has to cross two ridges, the Imam Raza, at a height of 1,366 feet, and Tul Khayaat, at a height of 1,308 feet, above sea level, before it passes through the foothills on to the desert. Tembi, it should be stated, is 618 feet above sea level.

The problems of the pipe line are, as may be expected, mainly engineering problems calling, at times, for the highest skill and ingenuity. The sections of steel pipe are screwed into one another and the most frequent difficulties arise from breakages in the pipe line due to alternate expansion and contraction, caused by the wide variation of temperature from winter to summer. The pipe line is curved at suitable places to enable the line to take up these expansions and contractions without fracture. Valves are introduced at intervals for stopping or regulating the flow.

It may be mentioned that, though the construction of the pipe line is nothing novel in engineering practice, the Company has evolved, for the various parts needed, its own standard specifications, which are markedly high in relation to those generally employed, and the tolerances—i.e. the departures allowed from the standards set—are correspondingly narrow.

Oil, like water, will not climb a hill, and even on gentle downward slopes of the desert, the viscosity and friction are such that the flow would be too slow for practical purposes. The oil, therefore, has to be driven through the pipe line.

At Tembi there is a pumping station, equipped with modern plant and machinery, which, it is claimed, is not excelled, if equalled, in up-to-date efficiency by

any other pumping station in the world. The fuel for steam-raising is the natural gas from Fields and much experimental work is being carried out as to the best types of burner, furnace and boiler for the gas under these industrial conditions. The pumps are powerful centrifugal pumps driven by steam turbos. They discharge the oil at a pressure of 600 lbs. to the square inch and drive it as far as the next pumping station, thirty-eight miles away, at Mulla Sani. By the time the oil has arrived at Mulla Sani the pressure, owing to friction and other causes, has dropped to from 20 to 30 lbs. to the square inch. At Mulla Sani, therefore, the pressure is "boosted up" again to 600 lbs. to the square inch, to drive the oil through another thirty-two odd miles of pipe as far as Kut Abdulla. Here another boosting station sends it to Dorquain, thirty-five miles distant, whence, by a final boost, it is driven thirty miles to the Bahmashir, a tributary of the Shatt el Arab, near to Abadan. Thence it goes to the crude oil storage tanks on the fringe of the refinery.

It should be explained that, in order to secure flexibility and to maintain average throughout, at each pumping station there are storage tanks of such capacity that, should there be pipe line or station troubles, the next station below can continue for some time to be supplied with oil, while repairs are

being effected, and the oil entering the station immediately above can be stored until the lower station is ready to receive continuous supplies.

There was one problem in connection with the pipe line of sufficient scientific interest to be worth mention here. In the early years serious difficulties arose because of the corrosion of the pipes crossing the desert. Long lengths of the pipe line were put out of action by corrosion after only twelve months' use. The question of finding, by experimental investigation, a suitable protective paint was considered, but it was realised that, assuming that a suitable paint were found, the coating would probably have had to be renewed annually and the cost would have been great, perhaps prohibitive. The solution was found otherwise; it provides an excellent example of the combination of acute observation with common sense—one form of science, it may be hoped.

The desert crossed by the pipe line is, of course, not all flat. It has slight undulations. It was noticed that the pipe line was nearly always most corroded where it rested on the crests of these undulations and least corroded where it touched the lower flanks of the undulations. It was well-known that the soil of much of the desert traversed is impregnated with common salt—the traveller cannot fail to notice the salt as a

white incrustation often stretching for miles. The deduction was hazarded that, when rain fell, the crests of the undulations, off which the water ran rapidly, had little of the contained salt washed out; whereas the soil of the lower flanks, through which the water percolated and flowed freely, was probably freed of salt by the mere washing; and that the salt was the primary cause of the corrosion. The fact, also noticed, that a Persian gardener was in the habit of sweetening his garden soil by letting water run freely through it added point to the hypothesis.

Polished pieces of steel tubing were accordingly buried, some in washed soil and others in unwashed soil; the former showed little or no corrosion, the latter the usual corrosion, after the period allowed for this rough test. In this way the deduction as to the cause of the corrosion of the pipe line was held to be confirmed and the cure was sought, and found, by digging a channel in the earth around the pipe line and letting the periodical rains wash out the salt from the soil about the pipe.

Before we leave the pipe line, attention may be drawn to the scientific treatment of another problem arising out of this method of transporting the crude oil. We have seen that pumping stations are required at definite intervals to boost up the pressure sufficiently to

maintain a steady flow of oil from Fields to the refinery. The pressure falls between one boosting station and the next, as has been said, from 600 lbs. to the square inch to 20 or 30 lbs., to the square inch. In order to secure the utmost efficiency of flow and to provide a safe margin for increasing the flow, if needs be, it is necessary that the pressure from station to station should, as far as possible, be graded, that is to say, drop gradually and continuously and not be liable to spasmodic or local rises. Otherwise it might happen that the pressure developed at some point would be the maximum pressure the pipe could withstand. Such a state of things, apart from the risk of breakage, would, of course, give no margin for increased flow. Accordingly a careful survey was made of the distribution of the pressures developed along the whole length of the pipe line and a graph was drawn showing the variations of the pressure along the line. By introducing extra parallel lengths of pipe at places where the graph showed local increases of pressure the graph showing the fall of pressure was smoothed out; in other words, the pressure drop along the pipe was made gradual instead of being jerky, and, in particular, the development of dangerous pressures at certain points was avoided.

The pipe line is the main artery through which flows

the liquid stream on which the very life of the Company depends. At Ahwaz on the river Karun are focussed, under the general direction of the superintendent of the pipe line, all those problems that arise as to the maintenance and improvement of that vital tube. These problems range from difficulties such as those just described to far reaching schemes for ever more efficient and economical transport of the crude oil from Fields to Abadan.

CHAPTER VIII

WATER, ELECTRIC POWER AND LIGHT

THE reader will have appreciated that, for the several large scale industrial operations that have been described, there are four primary needs—water, fuel, light and power. The provision of the fuel required at Fields has been described in the course of the gas story. It is time now to explain whence come the water, light and power.

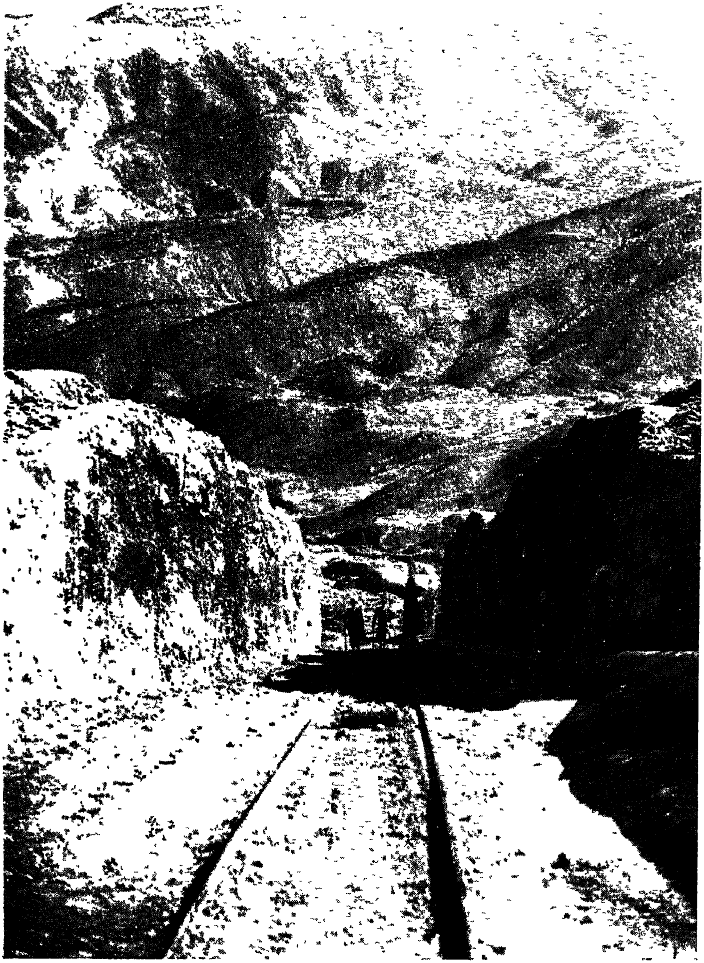
Until last year the main water supply for Fields was obtained from the river Karun at Dar i Khazinah. There a pumping plant drew the water from the river and drove it through mains, following generally the road and light railway to Fields, some thirty-eight miles away to the north-east. Now Fields water supply is drawn from a point higher up the Karun river, at Godar Landar, north of Fields and distant from Maidan i Naftun about twelve miles. The change has meant not only a shorter distance for the water to travel, but purer water at less cost. It is estimated that the water is obtained from Godar

Landar at one-fourth of the cost of getting it from Dar i Khazinah. The pumping station at Dar i Khazinah is still kept in being, as a standby in case of emergency.

It is rather beside our purpose to describe, in any detail, the engineering side of the Company's operations. The engineering problems are, of course, just as scientific as the other problems that have been or will be discussed, but they constitute a subject too great for the compass of this essay. A visit to Godar Landar is, however, such a notable excursion from Fields that it deserves a slight digression.

Leaving Maidan i Naftun, the centre of Fields, we motor along roads, constructed by the Company, which follow the chosen contours of the innumerable hills, and gradually climb to Tul Bazun. A little beyond this the road ends abruptly on the edge of a plateau, some 2,200 feet above sea level and terminated by a steep and rugged mountain side. Nearly a thousand feet below the edge there is a narrow valley, beset by bare hills, the strata of which outcrop vertically in rows upon rows of natural stone walls. Five and a half miles down that valley is the pumping station on the left bank of the Karun river at Godar Landar.

There is no road down the mountain side: to construct one would be impracticable. Our car is, there-



"THE SLIDE." TOP OF THE 2,200 FT. INCLINE LEADING TO GODAR LANDAR

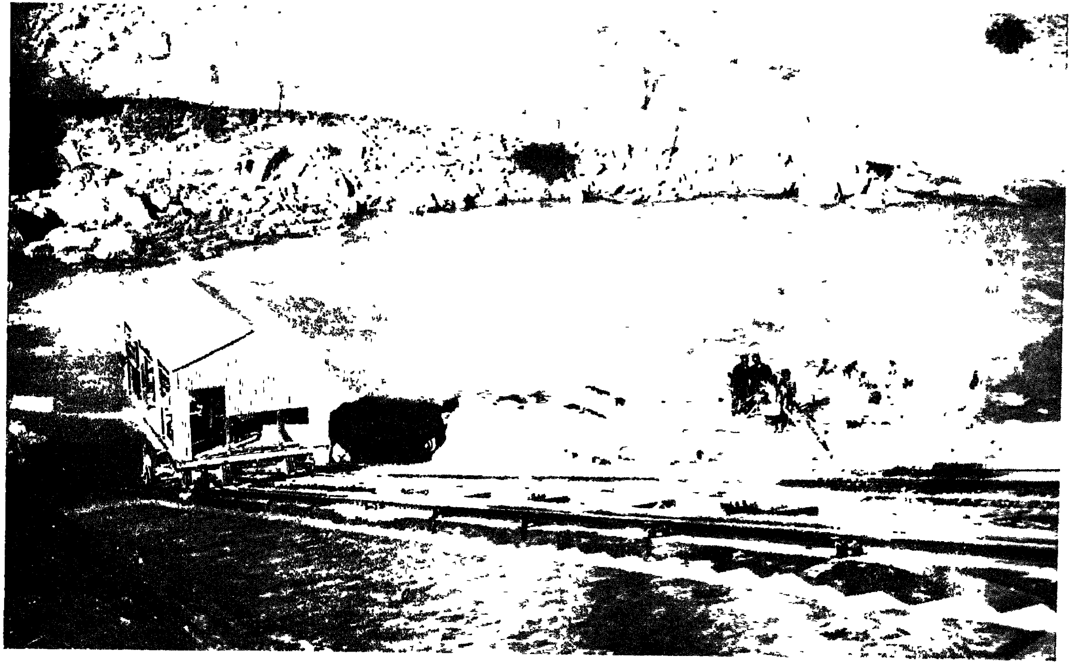
fore, left at the top and we proceed to slide down the mountain—with the help of suitable mechanical means. Rails have been laid, on sleepers, down a shallow cutting in the mountain side, from the top at Sar i Gach to the bottom at Par i Gach. The drop is about 950 feet and the length of rail 2,158 feet, giving a gradient of nearly 1 in 2. A simple four-wheeled trolley, held by a wire cable paid out from an electrically driven winding engine at the top, takes us down, and, when we return from Godar Landar, will bring us up. This is what they at Fields call "The Slide" and they are, justifiably, not a little proud of it. At the bottom a waiting car, summoned from Godar Landar by telephone, takes us down the valley to the pumping station.

The power at Godar Landar pumping station is electric and is derived from the Tembi power station which will be described shortly. The current is transmitted at 11,300 volts and is transformed to 440 volts for the motors at Godar Landar. The motors are of 350 horse power and centrifugal pumps send out the water at a pressure of 800 lbs. to the square inch. The whole plant is of the latest modern type and has sufficient power to pump a million gallons of water per day.

But perhaps the most interesting feature seen on

this fascinating trip is the means adopted to draw the water required from the Karun River. At Godar Landar the river, flowing over a rocky bed, is subject to great fluctuations of flow. A rise of as much as 45 feet in the level of the water may be expected in flood time. By an ingenious device, provision has been made to cope with a rise of no less than 70 feet. A steep, concrete slipway leads from the top of the high bank to the river bed. The pump house is built on a wheeled bogie, mounted on rails laid along the slipway. From a small house, on the bank above, winches draw in or pay out a cable which raises or lowers the pump house according to the rise or fall of the river, the electric cable transmitting the power to the pump house being drawn in or paid out at the same time.

From this rising and falling pump house the water is pumped into two large storage reservoirs, fitted with sluices and all modern appurtenances, and each capable of discharging half a million gallons of water. From the storage reservoirs the water is drawn, as required, and driven by powerful pumps through an 8-inch water main to the foot of The Slide and thence to the top at Sar i Gach, where there are storage tanks with a capacity of 6,400,000 gallons. From these tanks the water is led by mains to the Fields area for industrial and domestic use.



PUMP HOUSE ON SLIPWAY AT GODAR LANDAR

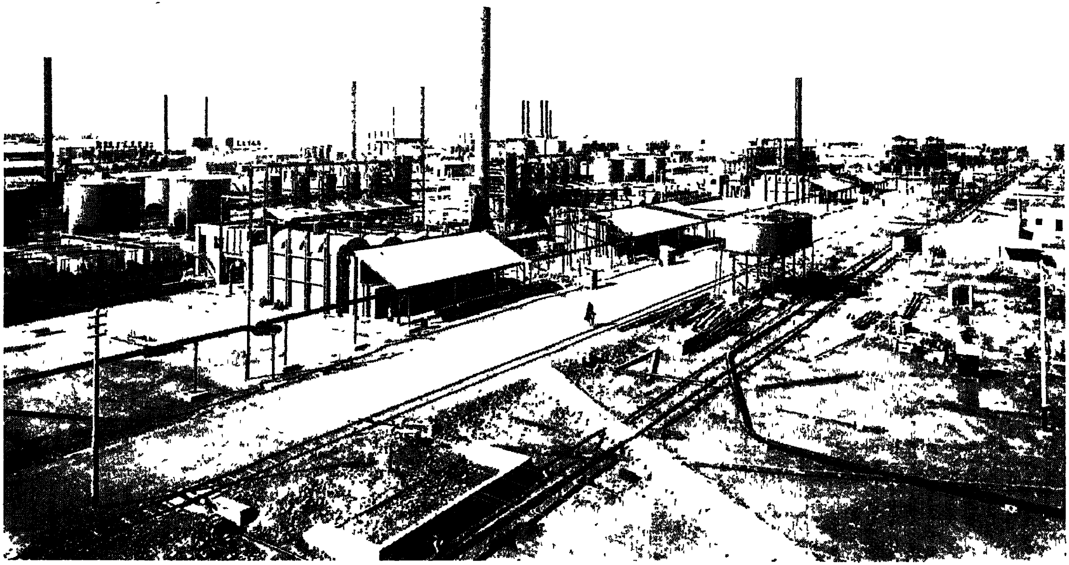
The whole design, construction and equipment of this new pumping station at Godar Landar, for which practically all the materials, including the girders and heavy machinery, had to be let down The Slide, leaves on the visitor's mind an abiding impression of efficiency and of triumph over physical difficulties.

To come to the question of the electric power and light, there is at Tembi, on the river Tembi, over against the great pumping station which has been described in the section on the Pipe Line, a great power station. It was begun in a modest way, provided with two dynamos, driven by reciprocating engines and yielding 350 kilowatts. As the cry for more power became urgent two steam turbo-alternators were added with an output of 1,500 kilowatts and, last December, another steam turbo-alternator, with an output of 3,000 kilowatts, was being installed, as well as the most modern type of switchboard. The fuel used is the natural gas from Fields.

The power is distributed by high tension overhead wires at about 11,000 volts to practically the whole area of Fields, as well as to Tembi itself and Tul Khayaat. Transforming stations, suitably placed, enable the voltage to be stepped down to the appropriate pressure wherever the current is required. It is interesting to note that the wide distribution over

Fields area of the high tension current enables electric power frequently, if not always, to be used for well drilling, which, as compared with steam power, results in economy of cost and accelerated drilling time.

The Tembi power station supplies the current also for the electric lighting of bungalows, offices and other buildings at Fields and for many miles of road lighting in that area.



ABADAN REFINERY

CHAPTER IX

REFINING THE CRUDE OIL

THE crude oil, it will be remembered, was left in the Storage Tank Farm on the fringe of the great refinery at Abadan. An attempt must now be made to indicate broadly the general character of the scientific work done by the Anglo-Persian Oil Company in obtaining from the oil the petrol, the kerosene and the other products, to provide which is the primary purpose of the Company's existence.

The reader should be warned afresh that this essay is not to be taken as a technical summary, or even a substitute for such a summary, of the methods of oil production and refining. In dealing with the scientific aspect of the work of the refinery it will necessarily be difficult to keep the narrative within the bounds set, for every step in refining is a scientific process and tempts some comment or explanation. It will be best, therefore, to confine our attention, for the most part, to some salient features of the scientific investigations that are undertaken at Abadan to

improve the processes of refining, selecting those that illustrate our general theme.

The crude oil as it reaches the refinery is, of course, a complex mixture of many compounds. It contains, actually or potentially, such substances, for example, as tar, pitch, paraffin wax, lubricating oil, fuel oil, kerosene or lamp oil, and petrol or motor spirit. Moreover, there is no hard and fast division separating, say, the fuel oil from the kerosene or the kerosene from the petrol. As we pass from the lubricating oil to the petrol, in the order just recited, we pass continuously from heavier to lighter fractions, i.e. from less volatile to more volatile products. The process of refining consists essentially in separating these fractions by distillation and in purifying the distillates obtained, by the removal of certain undesired ingredients.

At the Abadan Refinery there is a process chart showing the sequence and connections of all the refining operations. It is perfectly clear and intelligible, not only to the technician, but to the average visitor. Since, however, it looks as formidable as would a composite diagram of a genealogical tree and a railway junction, it is not inserted here. The reader who desires to have a resumé of the refining processes may read the following extracts, taken from a booklet published by the Anglo-Persian Oil Co., describing

the system of distillation at the Company's new refinery at Llandarcy, South Wales. It applies, *mutatis mutandis*, to Abadan.

> "The refining of petroleum is a lengthy operation, consisting in the first place of a distillation process for separating the oil into the various fractions from which, later, the petrols, lamp oil, lubricants, etc., are made. This is followed by chemical treatment for the purification of the several distillates, and sometimes, as in the present instance, by refrigeration for the removal of the solid paraffins and the subsequent refining of these by a heating process known as sweating.
>
> "For the first treatment of the crude oil, the continuous system of distillation is employed, the oil passing through various units in a constant stream. The most volatile fractions, which form the basis of petrol and kerosene, are first separated; then the others in order of their volatility. Maximum economy of fuel is secured by the introduction of heat interchangers, these utilising the heat from the vapours of the stills, and from certain residues to raise the temperature of the cold oil entering the system. . . . .
>
> "The progress of the oil through the refinery

is marked by changes of colour at every stage, and from the dull black crude, after the various processes have been completed, there comes the colourless petrol and gleaming white wax.

"From the tank farm the crude oil is pumped to the refinery, where it passes through the first distillation process already referred to, the distillate, from which petrol and kerosene are derived, being practically white in colour.

"The residue flowing from this series of stills may be disposed of as fuel oil, or it may be fully refined and converted into the various heavier products which it contains, such as gas oil, lubricants, tar and pitch." . . .

"Following the distillate from the crude oil stills, it is transferred to the benzine refinery, and there agitated in an upright vessel, known as a washer, with a solution of caustic soda, being partially deodorized in the process. The distillate so treated is then passed to the benzine rectification stills, where it is split into such fractions as the market demands at the moment petrol and kerosene.

"The petrol, even at this stage, has still a fairly strong odour. It is returned, therefore, to the benzene refinery, where it receives its final

treatment to remove sulphur and to deodorize it. In this process the petrol is agitated with a solution prepared by electrolysis, this solution being prepared at the refinery in a special section of plant.

"The final product is the clear spirit, known to the motoring public as 'B.P.'

"The kerosene or lamp oil, undergoes a special filtration process through granular bauxite, prepared in a particular manner. From this process the oil comes sweet in odour and perfectly colourless, being, in fact, the highest grade of kerosene.". . . .

"A portion of the heavy residue from the crude oil stills goes to other specially constructed stills, where the intermediate and heavier fractions are separated. The heavier part, containing solid paraffin and lubricating oils, is refrigerated, being cooled to a low temperature in an elaborate and specially-arranged system of coolers. This unit is known as the paraffin extraction plant.

"Having been reduced to the desired temperature, the frozen oil is pumped under pressure through filter presses, where the solid paraffin is deposited while the filtrate containing the lubricants exudes through cloths.

> "On removal from the presses the crude paraffin, technically known as 'scale,' undergoes its whitening process the first stage of which is known as sweating. The final stage consists of filtration through bauxite, in which the colour is removed.
>
> "The filtrate from the paraffin extraction plant, known as blue oil from its dark bluish tinge, passes to the lubricating oil distillation plant, where it is split up into various grades of lubricating oil, each grade receiving a finished treatment either by means of chemicals or by filtration."

At the Abadan refinery there are a staff of chemists and chemical laboratories under the charge of a chief chemist. As in the case of the Fields chemical staff so here there is complete liaison and a rotation of staff between Abadan and the research station staff at Sunbury-on-Thames. A good deal of routine work is necessarily carried on, for example, in the daily testing of the various products at each stage of the process. What, however, is more to our purpose is to note the recognition by the Company that there is, and can be, no finality in any of the processes adopted. A sleepless scepticism of the perfection of existing

methods is the price of progress. Research is prosecuted continuously into methods of improving every stage of the process and also to secure adjustments and modifications needed to meet special demands or particular difficulties arising out of the nature of the material being treated.

A considerable part of the refinery plant at Abadan, when the writer was there, was being reconstructed, in order to bring it into line with the new knowledge gained, not only from these researches, but also from the co-ordinated investigations undertaken at home and from the experience acquired in the new refinery at Llandarcy. A bare indication, in general terms, of some only of the objects to be gained by these modifications of the plant may be given here.

In the first place more accurate "cuts" are sought, i.e., sharper distinctions between the different products obtained, so as to obtain greater uniformity of each product and a greater number of intermediate products. Provision is being made for the blending of intermediate products at appropriate stages so as to avoid waste and to secure the desired properties in the final products. Again, the reconstructions of plant aim at the elimination of certain re-distillation operations by the substitution, as far as possible, of one continuous process for several independent processes.

There is also to be an extended use of heat interchangers, in order to increase fuel economy.

In some of these matters the Company is merely following developments of world knowledge and practice in refining; in others it is the pioneer.

It may be noted that in the first distillation of the crude oil a good deal of gas is evolved. This gas goes to a gas recovery plant to be stripped of its gasoline content by a method different from that which has already been described as employed at Fields. The term "gasoline," it should be explained, is used somewhat loosely in oil terminology. At Fields, as we saw, the gasoline is recovered from the low pressure gas by a process of absorption. At Abadan the gasoline is a very light fraction obtained by a process of compression and condensation from the gas evolved at the first distillation bench, which is not identical with the low pressure gas at Fields. This recovered gasoline is purified and introduced at the appropriate stage of the general refinery process to contribute its quota to the final products obtained.

There is, too, at Abadan a semi-large scale plant for investigations on the pyrolysis or cracking of the gas, stripped of its gasoline, on lines similar to those followed at Fields, with a view to getting from the lightest fractions of the gas by a sort of synthesis—" poly-

merisation " is the chemical term we are trying to avoid—heavier liquid fractions, among which benzole may again be mentioned. The introduction of benzole as an ingredient in the motor spirit, it may interest the motorist to learn, is to meet the needs of highly specialised internal combustion engines. When we come to describe the research work done at the research station at Sunbury-on-Thames we shall see that investigations are being undertaken into the varied and extensive problems raised by the use of motor spirit in internal combustion engines.

When, therefore, the pyrolysing or cracking plants, both at Fields and at Abadan, are in full scale working order there will be obtained from otherwise waste gas abundant supplies of useful and needed liquid products. Among the important by-products obtained in the course of the refinery processes at Abadan carbon bisulphide may also be mentioned.

One feature of the refinery plant is worth mention as an instance, among many, of the adoption of modern efficient machinery. The oil and the various intermediate products travel to and from the numerous units in the refinery plant through an intricate maze of hundreds of miles of pipe—almost as bewildering to the layman as the connections of a telephone exchange. This vast circulatory system is main-

tained by the use throughout the refinery of electrically driven, centrifugal pumps for all pumping purposes.

There is, of course, at Abadan an electric power-station, as well as a pumping station for the industrial water supply, drawn from the Shatt el Arab. The fuel used for steam raising is oil, though a certain amount of the stripped gas evolved in the distillation process is also so used.

Nor is artistic amenity forgotten. In front of the chief administration offices at the refinery Persian labourers were busy last December in levelling and laying a great grass plot for no other purpose than to gladden the eye. It may be added that, whatever there may have been characteristic of the East in their bare-footed methods of turf laying, they evinced a Western appreciation of rest pauses.

CHAPTER X

RESEARCH STATION AT HOME

THE salient features of the scientific work done in finding, getting, transporting and refining the crude oil have now been broadly reviewed. We have seen that both at Fields and at Abadan the chemical staffs and the work they do are brought into co-ordination with the scientific investigators and the research work done at the chief research station at home. Before leaving the more strictly scientific aspects of the Company's activities, in order to describe the not less important or significant work on the educational, health and social sides, it will be well now to describe the general character of the work done at Sunbury-on-Thames.

The decision to establish a research station was taken in 1915. The selection of the site chosen—eighteen miles from London—was determined by the consideration that the research staff must be in the closest personal contact, not only with the nerve-

centre of the Company's organisation in London, but also with the most recent developments of scientific thought and activity, the most eminent of scientific societies and the most complete and up-to-date of scientific and technical reference libraries. These latter things, it is needless to say, are centred in London.

In view of the necessarily wide and varied range of the scientific investigations to be undertaken, the Station was laid out as a group of separate buildings, each of which was designed and equiped for a specific type of work, ranging from pure chemical research on the individual chemical substances present in petroleum and pure physical research on the theory of lubrication to long-period tests on Diesel engines and complete refining of crude oil on a scale up to one ton.

The chemical laboratories, with the library, drawing office and engineering shop, constitute the central block of buildings. There are also the experimental refinery, the power house, the boiler house and the experimental house.

A good deal of analytical work is necessarily done in the regular testing of samples of the crude oil and of the various refined derivatives, as well as in the examination of specimens of oils, waters and mineral

deposits sent home by the Company's geologists and engineers.

Moreover, careful analytical control and record is kept of the quality of such items as refining chemicals, water and water-softening components, building materials, steels and other alloys, paints, enamels and the hundred-and-one miscellaneous articles used in the various activities of the Company. An important phase of this work is the development of improved or new methods of analysis, several of which have been subsequently adopted officially as British standard methods.

In the chemical laboratories new ideas, new materials and new processes are tried out on the "test-tube scale," i.e., with ounces, or smaller quantities, of material in glass apparatus. In the experimental refinery these experiments can be translated to a larger scale in steel plant which is a replica on a reduced scale of the still larger units of the commercial refineries. Thus it is possible, after a preliminary examination in the laboratory, to distil a relatively large quantity of any new crude oil and to prepare from it all the main derivatives in a refined condition, on a scale which is nearer to refinery conditions and which is of greater guidance than a laboratory test alone can be.

Before indicating some of the outstanding features of the research problems dealt with at Sunbury (and these range from entomology to boiler insulation and from atomic physics to gas masks) it is worth while to draw attention to one section of the research work, significant of the wide and long views taken by the Anglo-Persian Oil Company as to the scope of the researches that may legitimately be undertaken.

The petrol and the heavier fuel oils produced are, of course, destined for industrial use in internal combustion engines. The problems of the oil to be used and of the engine that is to use it are regarded as being so closely related that no researches into the one can be complete without correlated and simultaneous researches into the other. Diesel engines of different types are installed in the power house and these not only generate the electric power used by the research department, but are also used for investigations on Diesel fuels and on lubricating oils. Thornycroft and Ricardo experimental petrol engines are also erected in this house. These are single cylinder engines so constructed that not only can every factor which influences the running of an engine be individually controlled and measured, but the compression ratio can be varied between 3.8 and 8.0 while the engine is

running. These engines are coupled to dynamometers and are used for studying the behaviour of all kinds of motor spirits under all kinds of engine and atmospheric conditions.

The range of information on fuels obtainable from such engines is so great that it is applied not only to ordinary motor car practice but to the fuel problems which have been created by racing car, aeroplane and airship engines. The problem of the use of oil or motor spirit in internal combustion engines is thus investigated, simultaneously and in co-ordination, from the oil side and from the engine side—just as, in driving a tunnel through the Alps, the boring proceeds at the same time from both ends.

The research work undertaken at, or directed from, the chief research station at Sunbury goes, however, far beyond the utilitarian aims that have been indicated. It is obviously useful and indeed, important to discover how to test fuels and to adapt them to give the most efficient service in an engine; or, conversely, how to design or adjust an engine to yield the best service with a given fuel. But the aims and aspirations of the research chemist are not satisfied until answers are obtained to the more profound questions: Why do these adaptations produce the desired results and what is the fundamental mechanism under-

lying the whole process of combustion or explosion in the cylinder of an engine? Not only the "how" but the "why" has to be known, if the experimental work of the research chemist is to be directed by a logical sequence of thought, founded upon a definite basis of scientific facts, and not be a mere haphazard empiricism, following a "hit or miss" procedure.

We find, therefore, that fundamental research, as distinguished from directly utilitarian investigation, constitutes no small proportion of the activities of the Company's research department. Such work is necessarily of an intricate and even recondite character and demands research workers of the highest order, in knowledge, training, skill and experience. The research department of the Anglo-Persian Oil Company, therefore, has wisely sought and maintained close contact with those universities which specialise in the particular type of problem under investigation. Thus fundamental research on the mechanism of flame propagation in an engine cylinder is being carried out in collaboration with the fuel department of the University of Sheffield, which has already contributed greatly to our knowledge of this subject. Other lines of fundamental research at present in progress are concerned with the nature and

mechanism of lubrication and with the actual chemical entities of which petroleum is composed.

The Company has a scientific advisory council, consisting of Professor Thorpe, Professor Wheeler and Professor Lees, on the chemical and physical sides, and of Sir Thomas Holland and Professor de Bōckh, on the geological side, for constant consultation in the initiation, prosecution and correlation of the vital fundamental researches needed.

Nor has such an apparently academic and remote problem as the origin of natural petroleum been ignored. Contributions on this subject have been made to learned Societies by members of the research staff of the Company. The question is not so academic as it seems. As was said by a writer in *Nature*, "the problem of the genesis of petroleum has a distinctly practical significance for, if solved, prospectors for mineral oil would be provided with important data and chemists might learn how to produce artificially valuable substances similar to, if not identical with, natural petroleum." The same writer, it may amuse the reader to note by way of diversion, unearthed the following early contribution to this perplexing problem: "A Polish cleric, named Kluk, traced the origin of petroleum to the Garden of Eden, which was so fertile that it must have contained fats: at the

Fall this fat partly volatilised and partly sank into the earth, where it was finally transformed into mineral oil by the changes induced by the Flood."

To return to our more serious record, the reader will have already appreciated the vitally important part which the scientific, and perhaps especially the chemical, headquarters must play in a petroleum company of the magnitude of the Anglo-Persian Oil Company. Problems of an essentially scientific character are continually arising in connection with the Fields, the transport and storage of the crude oil, the initial distillation, the refining of the intermediate products, the distribution of the finished article and its ultimate utilisation by the consumer. Some of these problems can be more or less rapidly solved at the central research station at home; sometimes they can be more conveniently investigated at the refineries; and sometimes, again, Fields research station at Maidan i Naftun is the most suitable centre for their treatment.

It has already been pointed out that there is complete liaison and co-ordination and a rotation of staff between the various research stations. If occasion demands, a research chemist who has made a special study of the particular problem at Sunbury is sent to deal with it on the spot and, conversely,

chemists home on leave from outside areas invariably take, in part, a "busman's holiday" and are attached to the central research department for a period. In this way each chemist in the Company's service is enabled to learn at first hand the lines of thought and of progress in his profession and to discuss his ideas and his problems with his brother chemists. The senior chemists in England visit the refineries and Persia at regular intervals and a general chemical conference, attended by representatives from every chemical centre in the Company's organisation, is held in London each year. The co-ordination of the activities of the Company's chemical staff is one of the most important functions of the central research department and its success is attested by the enthusiasm and esprit de corps which, it was evident to the writer, animated the Company's chemical service no less than the other services.

It should be added lastly, in considering the more strictly scientific side of the Company's activities, that the Anglo-Persian Oil Company's research department, with the full approval and encouragement of the directorate, does not forget its obligations to the cause of science as science. The results of the varied investigations are published to the scientific world, except, obviously, where the work is necessarily of a

confidential character. In general, however, the records of the fundamental researches after scientific truth are presented to the Chemical Society and other learned societies, as the research department's quota to the world's scientific knowledge. Furthermore, the senior members of the chemical and other scientific staff are associated with the activities of advisory, scientific committees of various Government departments and in this way their knowledge and experience are put to the service of a wider circle than that of their own Company. In this connection it is worthy of note that the Chairman of the Company, Sir John Cadman, has been for many years a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research, which is, in a far from fanciful sense, the scientific senate of the nation, constituted of a chosen few of the country's leaders in science, and charged with the fiduciary duty of promoting the application of science to a wide field of governmental activity and to a broad and diversified area of British industry.

PART II
THE HUMANITIES

BAKHTIARI CROSSING THE KARUN RIVER ON RAFT OF INFLATED GOAT SKINS

CHAPTER XI

THE HUMAN MATERIAL

It was stated in the introduction that, in considering the application of science to industry we should interpret the word science in its widest sense, so as to include the methods of dealing, not only with the raw material obtained from the crust of the earth, but also with the human and sociological factors necessarily involved in large-scale production. Enough has already been said on the problems flowing from the crude oil. We have now to turn to the ways of dealing with the human material and of building a social structure out of it. If the first part of this essay may be called the science, what follows is the humanities, of a great industrial undertaking.

It is obvious that for the operations that have been described it was necessary to secure the willing co-operation of the Persians in whose country those operations were to be conducted. In particular large supplies of local labour were essential for the pioneering work, such as the transport of heavy

machinery, pipes and other materials; the erection of the derricks, houses and other buildings; the construction of roads, bridges and railway. The peculiarity of the problem that faced the Anglo-Persian Oil Company from the start lay in the character of the human labour available.

The inhabitants of that part of Persia (Khuzistan) in which the work was to be done were, for the most part, pastoral nomads, consisting mainly of the famous Bakhtiari tribes. The Bakhtiari follow the grass. As summer approaches to scorch the grass on the desert plains, they migrate with their flocks and herds, over the foothills, across the bridgeless rivers and over the snow-clad mountain ranges, to the high lands where grass is then to be found. In the late autumn when the grass dies down on the high plateau or in the mountain vales, they trek back to the low-lying plains, where, in the mild winter, they can find enough grass on the desert to feed their flocks. They live in tents or in rude shelters constructed of sun-baked mud or of the loose sandstone and shale of the hills. Their wants are few and the hardships of such a life are to them scarcely irksome. Of money they have little need and such exchange as they require is done largely by barter.

This part of Persia corresponds roughly to the

ancient Kingdom of Elam. There was a time when, as in other parts of Persia to-day, a settled agricultural population dwelt here. Remains of ancient irrigation canals are still to be seen on each side of the Karun river. But the nomadic life of the Bakhtiari is the consequence of successive waves of invasion from the north and west—Babylonian, Greek, Roman, Arab and Turkish—destroying the agricultural resources of this region, which may become yet as fruitful a part of the earth as is, for example, Egypt to-day.

It was from this nomadic human material that the company had to enlist the labour it required. The character and habits of these tribesmen presented human and sociological problems as peculiar and as complex in their own ways as the physical and chemical problems raised by the nature of the crude oil obtained from below. It was not sufficient to attract the tribesmen to service with the Company by the prospect of regular pay and the additional comforts that pay could bring; measures had to be taken to keep them when enrolled. The nomadic instinct is not easily extinguished. Gradually they came in increasing numbers into employment and problems immediately arose as to their health, their housing and their training. We will take these problems in this order.

CHAPTER XII

MEDICAL SERVICES

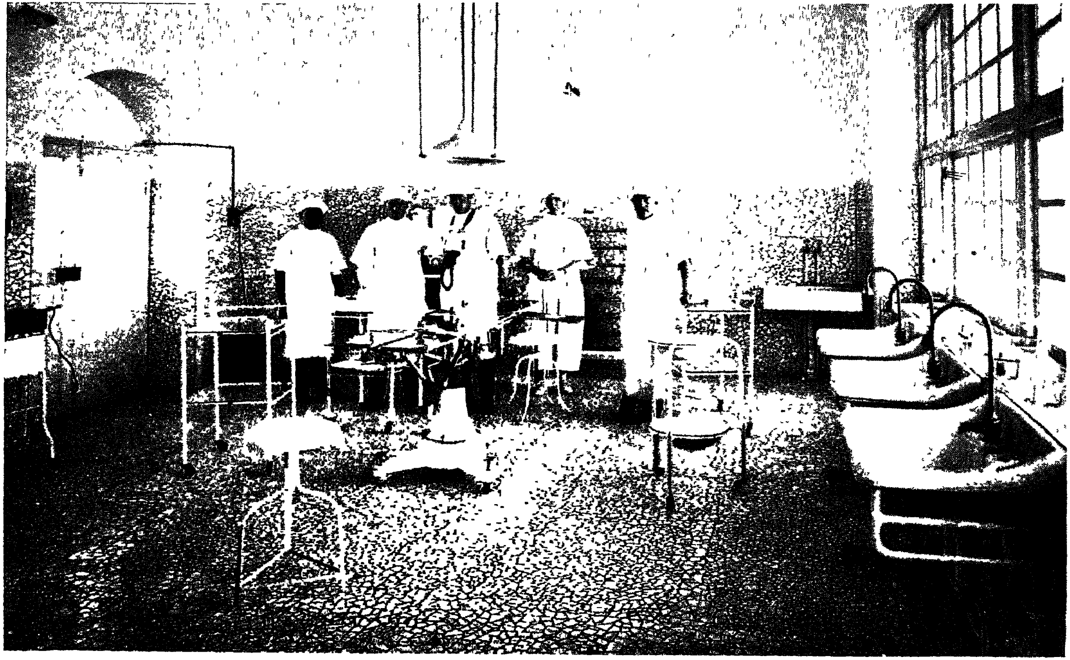
FROM the outset it was recognised that proper provision for dealing with sickness was at least as important as attractive pay. It is significant that one of the earliest administrators sent out by the Company was a medical man, Dr. M. Y. Young, and it is not less significant that he did not confine his interest to the purely medical sphere, but pushed out into a sympathetic study of this ancient people, of their language, history, customs, habits and ways of thinking. There is now a specially organised department of the Anglo-Persian Oil Company which takes within its province, not only the legal and other formal relationships between the Company on the one hand and the Persian Government, the local officials and individual Persians on the other, but also the study of the human side of the people with whom it has to deal. The gradual growth, from simple beginnings, of the present elaborate medical and surgical service and hospital equipment deserves to be

told in detail. We can attempt here only to picture the state of things to-day.

At Fields, at Ahwaz and at Abadan the Company has built, equipped and staffed hospitals, which it maintains entirely at its own cost and which provide medical and surgical treatment not only for the sick employees of the Company—whether Europeans, Persians, Indians or others—but also for those, of whatever race, having little or no direct connection with the Company. A general description of the hospitals and of the healing work done, at Fields and at Abadan, may now be given. With a few qualifications, the general features apply also to the hospital at Ahwaz.

FIELDS AREA

The hospital for in-patients at Fields is situated some two miles from Maidan i Naftun. It has the following accommodation: for administrative staffs 27 beds; for workmen, 57 beds. In addition there is a special ward of two beds for European ladies and another ward of two beds for clerks' wives. An out-patient department and dispensary is attached. There are, too, a dysentery hospital for clerks and workmen: an isolation hospital for Europeans and a small-pox and other infectious diseases camp.



THE OPERATING THEATRE AT THE OIL FIELDS HOSPITAL

The hospital stands well back from the road in its own grounds and is a one-storied building of local stone and gach, with deep verandahs surrounding the several wings. It contains two surgical operating theatres, one for septic and the other for aseptic cases; a pathological and bacteriological laboratory and an electro-diagnostic department with a complete X-ray outfit. The walls and floors of the operating theatres, by the way, are a gleaming white mosaic of broken bits of crockery. Whether this is a brilliant use of waste material, or whether the crockery is deliberately broken for these utilitarian ends, the writer cannot remember. The result is a marvel of cleanliness.

A heat stroke wing was in course of erection and nearing completion, with means for maintaining the temperature at 80° F, in order that a special study may be made of the nature of heat stroke, the general knowledge of which is not by any means complete or definite. The sanitary and ventilating arrangements throughout the hospital are modern. It is proudly claimed, and the writer can well believe it, that Fields hospital is not only the best equipped hospital in Persia, but that it is probably better equipped than are many hospitals in India.

It is told of a Scottish inhabitant, proudly showing

the English visitor round a Highland kirkyard, that he crowned his enthusiasm for its beauty with the remark: "When I was a young man, it was considert a great treat tae be buried here." Without going quite so far in appreciation as that, it may be said that a patient in Fields has at least as good a treat as has a patient in many a London hospital.

Facilities for medical treatment in Fields area are afforded also by a number of dispensaries, where the very large number of out-patients are treated and the more serious cases selected for admission to hospital. There are nine of these district dispensaries at a distance from the hospital varying from two to twenty-six miles.

It should be pointed out that the medical and surgical service in the Fields area is free of charge for all employees either as "indoor" or "outdoor" patients, and that free indoor and outdoor treatment is also given to the local inhabitants and tribesmen who are non-employees. Dental treatment is also available for all cases. In this connection it is interesting to note that the local inhabitants and tribesmen have shown a growing confidence in, and an increasing willingness to take advantage of, the facilities offered. At first there was the usual suspicion and timidity in face of the unknown. It has needed tact, sympathy

and skill to achieve this result. The value to the Persians of this developing appreciation of modern medical and surgical science is obvious and must have beneficial reactions reaching beyond the immediate area of Fields.

The medical staff comprises a senior medical officer, two resident medical officers and a visiting medical officer. The services of specialists are also available, namely, a consulting surgeon, a pathologist and an ophthalmologist. There is a graded nursing staff of twenty-six under the charge of a European matron assisted by eight European sisters.

The term "European" employed here and elsewhere in this record, it should be explained, has less reference to what the schoolboy understands by "Europe" than to the British Isles, not excluding the northern part of Britain.

The following figures, representing patients treated in Fields area during the year 1926, will give some idea of the extent and variety of the work of the medical and surgical staff in Fields:

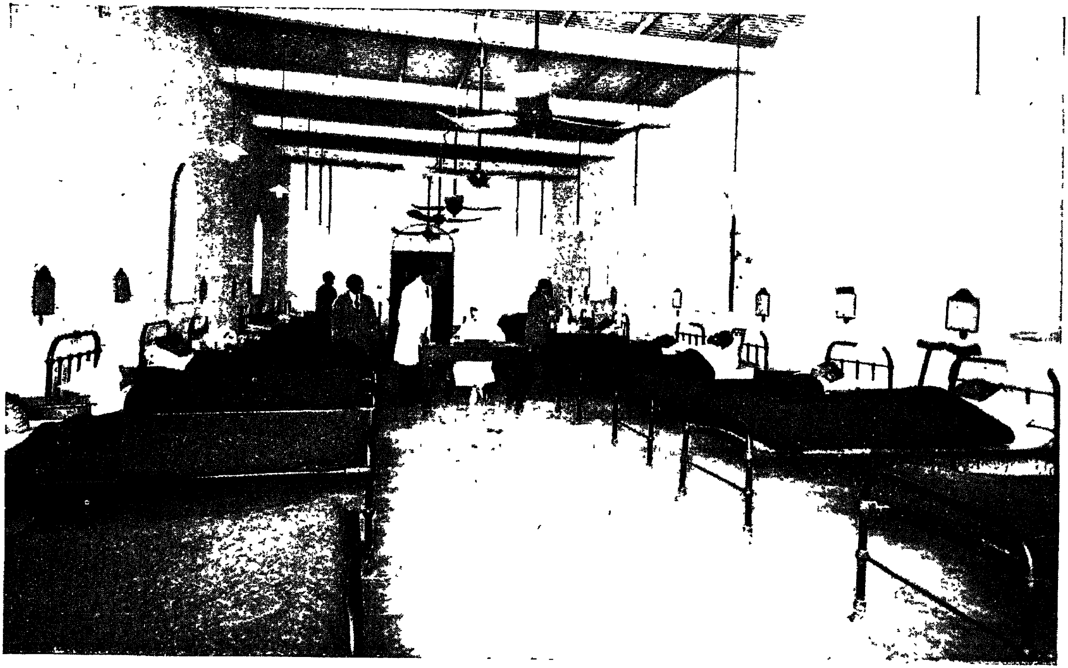
Hospital in-patients		1,666
Out-patients:	(a) new cases	38,270
	(b) Attendances	88,913
Major operations		290
Minor operations		1,378

Pathological examinations 6,039
Dental (new cases) 607
X-Ray photographs 483

ABADAN AREA

The medical service in the Abadan area provides, as we saw was done in Fields, free medical and surgical treatment, either in hospital or as " out-door " patients, for all employees of the Company and also for local inhabitants and non-employees. It is responsible, in addition, for the health of the port of Abadan, situated at Bawarda, two miles south of Abadan on the river Shatt-el-Arab, where all the oil tankers and other vessels coming alongside are inspected and all shipmen requiring medical attention are treated by a resident port medical officer. The public health of the area and all questions of sanitation in relation to the medical department are under the charge of a resident medical officer of health.

The general hospital for in-patients at Abadan has the following accommodation: for administrative staff, thirty-six beds; for workmen, sixty beds. In addition there are special private wards, an out-patient department and dispensary, a dental surgery, a surgical operating theatre, a pathological laboratory,



PERSIAN WARD IN THE ABADAN HOSPITAL

disinfecting station and an X-ray plant. There is, too an isolation hospital for infectious cases.

An independent mental block is being added to the general hospital with accommodation for two patients. There is also an isolation hospital and quarantine camp situated at Bawarda, and now undergoing enlargement, which affords accommodation for all infectious cases and contacts.

Dispensaries for the treatment of out-patients and for the selection of the more serious cases for admission to hospital have been established at Mohammerah, ten miles distant from the general hospital, under the charge of a resident medical officer; at Bawarda, two miles away from the hospital, under the charge of the port health officer; and in the refinery, under the charge of a medical officer. Another dispensary, in the European residential area, is in course of construction. It should be added that a medical officer makes visits to quarters when required.

The general observations made in the section dealing with Fields area, as to the growing appreciation of the medical and surgical services by the local Persian inhabitants, apply equally to the Abadan area; and the social benefits to Persia must be similarly diffused.

The Medical Staff and the Nursing Staff of the Abadan area are fairly comparable, in number and

grades, with those in Fields area, though we may note that there are also a medical officer of health and a port health officer. The specialist services of a consulting surgeon, pathologist, an ophthalmic surgeon and a dentist are also freely available.

Some idea of the work carried out by the medical department in the Abadan area is afforded by the following figures for the year 1926:

Hospital in-patients	2,228
Out-patients (a) New cases	40,129
(b) Attendances	137,169
Major operations	214
Minor operations	1,815
Pathological examinations	4,733
Dental cases	892
X-Ray photographs	99

In addition, tankers and other vessels are dealt with at the Port of Abadan at the rate of some fifty per month.

It should be mentioned here that proposals are under consideration for building, in substitution of the present hospital at Abadan, a new and larger general hospital near the Bahmashir river some two miles from the refinery, where there is more space and a healthier situation. The plans have already been drawn and the whole scheme is in keeping with the

comprehensive views characteristic of so many of the Company's undertakings. This new hospital, when built and equipped with the latest and best appurtenances, is to be the base hospital for non-urgent cases, so as to set free for urgent cases beds at Fields and Ahwaz hospitals.

. . . . .

What is, however, to our main purpose is not so much the scale and equipment of the buildings as the scope and spirit of the medical work proposed to be done. We have already seen that at Fields a special ward is being built for the study of heat stroke. It is proposed to undertake at Abadan and elsewhere in Persia a comprehensive bacteriological and pathological study of tropical and sub-tropical diseases and also of industrial disease in relation to the particular conditions of the Persian oil industry. For the purpose of these researches the investigators will prepare their own vaccines, their own inoculations and devise their own tests. It is true that much specialised study has been made, in England, for example, of tropical disease and of industrial disease, but the view held by those directing the medical services of the Anglo-Persian Oil Company is that, just as the vital activities of human beings re-act to climatic conditions, so may the physiology of the bacteria and other organisms

causing tropical and industrial diseases be influenced, and even profoundly modified, by the local conditions, climatic and otherwise, to which they are subject. A thorough going research, *de novo*, as it were, should, therefore, be undertaken in the locality in which the specific diseases are encountered. The plans of the projected new hospital on the Bahmashir river include generous provision for the laboratory accommodation and other facilities needed for these far reaching researches. It is, of course, at this stage impossible to predict what will be the outcome of these investigations, but it is equally impossible not to be struck by the large and imaginative view taken of the desirability of such work.

CHAPTER XIII

PUBLIC HEALTH

To the foregoing account of the medical services provided for individuals we must now add some record of the complementary services conveniently grouped under the heading of public health. To prevent misunderstanding, it should be stated here that what follows applies only to the areas of the Company's operations. Elsewhere the public health department of the Persian Government safeguards the health of the Persian communities, as, for example, at Abadar town, adjoining the refinery area.

There is thorough and systematic conservancy work, in order to keep within control the ubiquitous fly and other disease carriers. Anti-malarial work proceeds on scientific lines, and, in the report of the Company's medical and public health serfice for 1925, it was stated that a distinct improvement in the reduction of mosquitoes was marked at the end of the year. Unfortunately, Abadan is so situated that the work is much hampered by winds bringing mosquitoes from the desert marshes and from the far side of the Shatt-el-Arab.

Anti-plague measures, such as house fumigation, rat-trapping and baiting, are regularly carried out and during 1925 no less than 28,157 rats were destroyed. It may excite the humorous interest of the reader to be told that this Oil Company has even an official rat catcher. Post-mortem examination is performed in every suspicious case and slides are examined microscopically for B. Pestis. None of these tests, during 1925, proved positive. Strict control is maintained over all cemeteries and no burials are allowed without the authority of the public health department. In this way the special infectious diseases as the cause of death among non-employees can be ascertained or ruled out.

Disinfection of clothing by steam and fumigation of houses by sulphur dioxide are the methods of procedure in all cases of infectious diseases. When smallpox is present to any extent, the clothing of native labourers working on the ships in port is disinfected before they are allowed to proceed on board. The clothing of 700 labourers was so treated in 1925.

All employees from the United Kingdom are vaccinated and inoculated against enteric group diseases before leaving home. Similar steps are taken with all employees from India on arrival at Mohammerah, the second dose of T.A.B. being given in the area to which

they are posted. Approximately 5,000 vaccinations and inoculations were carried out in Persia during the year 1925, in addition to those recorded in the statistical statement below.

The normal sanitary inspection is another feature of the public health work. It is noteworthy that at Abadan, and especially in the Refinery area, a whole series of dry latrines has been converted into a water-borne system. This has enabled a reduction of the sanitary staff to be effected and has done away with the old noxious method of night-soil removal. In this connection it is interesting to note that tact and persuasion were needed before the local labourers could be brought to overcome their natural and habitual prejudices in favour of the superseded system. The traveller in the East will understand the difficulties here. It is enough to say that the design and construction of the water-borne system has ingeniously met the peculiar difficulties and the labourers, whether Persian or Indian, are now more than satisfied.

There is regular inspection of food and of water supplies and milk supply, with periodic collection of samples for analysis. Four soda water factories are kept under strict observation and control. To take a particular instance, the vegetable bazaar at Fields is inspected daily. It was the proud boast of one officer

of the Company that Fields vegetable bazaar is the cleanest bazaar "east of Suez." Without in any way belittling the implications of that boast, the writer, who had seen the bazaars at Damascus and Baghdad, may add that he found the statement easily credible.

An idea of the extent of the varied services performed in a year by the public health departments of the Company may be gathered from the following statistics, culled from the 1925 report:

Fields:

307 unauthorised buildings demolished as unsanitary.

700 rooms, buildings, etc., limewashed.

443 dead animals disposed of by incineration.

21,929 carcases of animals killed for food inspected and 3,083 parts condemned as unfit for human consumption.

2,481 lbs. of fruit and vegetables condemned and destroyed.

15½ tons of condemned provisions from stores incinerated.

1,748 vaccinations against smallpox with lymph supplied from the United Kingdom.

THE VEGETABLE BAZAAR BUILDING PROVIDED BY THE COMPANY AT MASJID I SULEIMAN

Abadan :

456 animal carcases, mostly recovered from the river fore-shore, incinerated.

3 tons of fruit, fish, meat and vegetables in the bazaars condemned and destroyed.

37 portions of animals slaughtered for food found unfit for consumption and incinerated.

1,269 vaccinations against smallpox.

Before concluding this survey of the public health services some reference should be made to the provision of a pure water supply and of a modern system of sanitation for Abadan. The river Shatt el Arab provides an abundant supply of water for steam raising and other refinery purposes but the potable water for domestic supply is drawn from the less contaminated Bahmashir river on the east side of Abadan island. This water is settled in tanks, filtered and treated by a modern chlorination process, in order to purify it, with the result that the tap supply of domestic water in Abadan reaches Western standards and is equal to, if not better than, any other domestic water supply in the East.

As to the sanitation there were inherent difficulties to be overcome, for the level of the land is in many

cases below that of the river Shatt el Arab, so that there is no natural fall for effluent. Moreover, because of circumstances that will be known to travellers in the Middle East, there is no "sweeper" class of labourers in Persia available for sanitary services in accordance with Indian practice, for example. In the bungalow area at Abadan, therefore, the latest form of sanitation has been adapted to meet the peculiar conditions. Septic tanks are provided throughout the area and are periodically cleaned by means of mobile vacuum tanks mounted on motor lorries. The system is a completely closed system so that there is no contact anywhere with the atmosphere. The septicised effluent is collected in concrete wells, 20 feet deep, the level of the liquid in these wells being subject to automatic electrical control, and is pumped thence into the river Shatt el Arab.

The thorough and comprehensive character of the varied public health services that have been summarised will be obvious to the reader. Their primary purpose is, of course, to ensure the efficiency of the productive work of the Company by checking and preventing disease. But they must also have some effect in stimulating the development of similar services in other parts of Persia. If plague spots tend to spread, so do health spots.

CHAPTER XIV

HOUSING

It has already been indicated that neither at Fields nor at Abadan was there any settled community worth mention before the Anglo-Persian Oil Company began its operations there. The large number and the varied types of the buildings now to be seen at Fields and at Abadan, for example, have practically all been erected by the Company. Broadly speaking, there are three main types of domestic dwellings, designed to provide suitable accommodation for three broad divisions of the Company's employees. There are spacious bungalows (mostly, but not always, one-storied) for the European staff; smaller bungalows for the clerks; and rows of stone, brick, or gach houses for the Persian labourers and artisans.

It may not be superfluous here to draw attention to two points. In England our domestic architecture is, or professes to be, bent on letting in the sun; in Persia one of the architect's chief concerns is to keep out the sun so as to prevent the dwellings from becoming in the

heat of summer veritable ovens. All the bungalows, therefore, are surrounded by deep verandahs and are designed to secure shade rather than light. The other point is in the nature of a *caveat*. The term " bungalow " is apt to sound on English ears as a name for a temporary or diminutive dwelling—a little more than a hut, a little less than a house. It should be understood, then, that the bungalows for the European and higher Persian staff are spacious and solidly built structures of brick or stone, with lofty rooms, ample accommodation, and every modern convenience. Electric light, electric heating and electrically driven fans are installed throughout, and at Fields there is laid on to each bungalow an abundant supply of natural gas. The supply both of electric current and of gas is so abundant, indeed, that no attempt is made to check by meter individual consumption.

Many of the bungalows have gardens. The writer hesitates to whisper it, but here one of his pleasant preconceptions perished. None of the gardens he saw—admittedly at the worst period of the year—gave assured promise of surpassing a typical English garden or of justifying the raptures of Omar Khayyam. It is sad to say it, but it looks as though the beauty of a Persian garden—in Southern Persia, at least—were a literary fiction or a poet's licence.

GROUP OF STAFF BUNGALOWS AT CHASMEH I ALI

The smaller bungalows for the large number of clerks set also a high standard of comfort and are much superior in accommodation and conveniences to similar housing provision in India, for example. The rows of solidly built dwellings for the Persian and other labourers are immeasurably better, in every housing way, than the primitive shelters, with walls of sun-baked mud and flat roofs of mud or reeds or palm leaves, that are the normal type of dwellings to be seen in the adjacent villages. At Fields there is attached to each row of the labourers' houses a common cook house, supplied with natural gas, burning as perennially as the flares. At Abadan a constant supply of fuel oil at present takes the place of the natural gas. Reference has already been made to the sanitation.

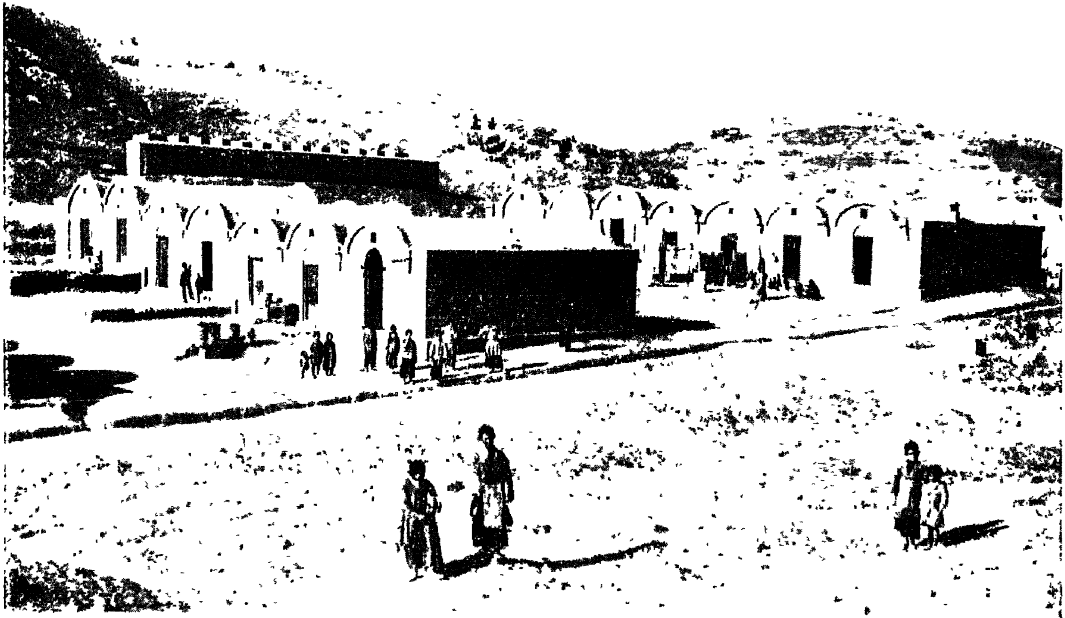
On the eastern side of Abadan there is now a model village, rapidly growing in extent, with rows on rows of sanitary well built houses for the numerous Persian artisans and labourers; and a large space of ground was being cleared last December preparatory to the laying out of a public park there, for the use of the village and other inhabitants.

It should be noted that, whereas at Fields there is abundant local building stone and gach available, at Abadan there is nothing but the alluvial desert, the

nearest natural stone being some 130 miles away. One advantage Abadan has over Fields—the river Shatt-el-Arab, which facilitates the discharge of effluent and assists transport. But practically everything for constructional building at Abadan—earth, lime, sand, cement and bricks—has to be imported. The Company has set up its own brick works, at Kut Abdulla, on the river Karun, where rows of great kilns provide the fire-baked bricks needed for the Company's manifold building operations.

Complementary to the provision of dwelling houses was the question of bazaars. It has been indicated that the prospect of regular pay, in the first instance, attracted the nomadic tribesmen to service with the Company. The wages, of themselves, could do little, however, to keep the men in service unless opportunities were provided of purchasing with the wages those commodities and comforts not obtainable in the nomadic life. It was not enough to give money; ways of spending the money had also to be provided. At Masjid i Suleiman therefore, the Company has erected model bazaars, at which the usual commodities—food, clothing, utensils, tobacco and ornaments—can be purchased. These bazaars are solidly built rows of shops with open fronts, of the general Persian type, and mark a great advance, in

SOME EXAMPLES OF THE HILL-SIDE DWELLINGS AT THE OIL FIELDS



TYPES OF HOUSES BUILT BY THE COMPANY FOR THE PERSIAN WORKMEN AND THEIR FAMILIES AT MASJID I SULLIMAN OIL FIELDS

solidity and cleanliness, on the ramshackle, makeshift bazaar buildings frequently to be met with in the East.

Before leaving the subject of housing we may be permitted one reflection. The housing accommodation provided for the Persian labourers is, as has been said, immeasurably better than that to which, before the Anglo-Persian Oil Company came, they were accustomed. It is safe to say that nowhere in Khuzistan, outside the area of the Company's activities, is the dwelling accommodation for the labouring class at all comparable with that provided by the Company. Is it fanciful to think that the example thus set, of a higher housing standard, will inevitably filter outwards and spread a civilising influence beyond the confines of the Company's specific activities?

To the writer, at least, there seemed to be evidence of some such process of diffusion. The journey by launch from Basra to Abadan, a run of some forty miles down the Shatt el Arab, is on a broad river lined on both banks by continuous—or all but continuous—groves of date palms, which stretch inwards for half a mile or more. Among small clearings in these apparently endless groves one sees numerous villages, the dwellings (if such a word be not too dignified for such primitive shelters) being made of mud

walls with flat roofs of plaited reeds or matted leaves, and all without doors or even openings for windows. But as the traveller comes off the island of Abadan it is impossible for him, if he be observant, not to be struck by an abrupt change in the character of the villages he sees. The dwellings are larger, they have sloping roofs of straw or reeds, suggestive of the thatched cottage of the English country side, and, what is more significant, they are furnished with doors and windows, though the windows may be unglazed. What is the explanation of this abrupt development if it be not due, in part at least, to some influence spreading outwards from a centre of civilisation in which there has been a marked development of the housing standard? When the traveller arrives eventually at Abadan and sees there the replica of an English port and notes the housing accommodation provided by the Anglo-Persian Oil Company for its Persian workers he can hardly fail to infer that here is the probable explanation. This impression, which the writer got spontaneously as he reached Abadan for the first time, was confirmed by all the information he acquired afterwards and it strikes the keynote of the social effects in Persia attributable to the enterprise of the Anglo-Persian Oil Company.

CHAPTER XV

EDUCATION

I. WORKSHOP TRAINING

WE have seen that unskilled labour was needed for road-making; for handling and transporting, by mule and ass, the machinery and the varied materials used in constructional work; and for assistance in the elementary operations of rig building and drilling. Beyond that, in order to supplement the European engineers sent out, a demand arose for local inhabitants with some engineering skill, as fitters, machinists, turners and moulders, for example. Some of these more skilled Persians came from Isfahan; others had picked up in other parts of Persia elementary engineering knowledge and skill. They were trained to the more specialised operations of the Company by European engineers.

It is, however, with the training of the young boys, many of them simple nomads, that we are mainly concerned here. The Anglo-Persian Oil Company has at Masjid i Suleiman, at Ahwaz and at Abadan

huge engineering workshops, which, in the multiplicity, variety and magnitude of the work they turn out, are comparable with the works of many a fairly large engineering firm at home. At each of these workshops young Persian boys are being trained, under the supervision of European engineers, in the varied operations of an engineering shop.

The Company has, however, made an attempt at training these young Persians more systematically than by merely putting them under individual supervision in the general workshop. At Fields and at Abadan definite Manual Training Centres or Workshop Training Schools—whichever term be preferred—have been established, under the direction of European engineer instructors. At Fields there were about fifty boys under such manual training and at Abadan an approximately similar number. The boys in these workshop Training Schools are trained either as fitters or machinists, and the usual run of elementray operations is followed, namely, chipping, filing, screwing, tapping, turning, etc. It was amusing at Abadan, by the way, to see three Persian boys turned loose on to an old Ford engine, with full leave to pull it to pieces, just to see how it came to be fitted together. No English boy taking his watch to bits could have been more absorbed.

PERSIAN APPRENTICE SCHOOL AT MASJID I SULEIMAN

The zest and interest these amenable young Persians take in their work is, however, not more significant than the obvious interest taken in them by their European instructors. Indeed the writer is fain to confess that, among the many things that impressed him on his visit, to which tribute has been or will be paid in this record, nothing seemed to him more "touched to fine issues" than what is being done in these workshop schools at Fields and at Abadan. The Company is doing many bigger things but it is doubtful whether it is doing anything of better import than this.

It was soon found that, to make the manual training effective, the boys, who are wholly illiterate, must be taught to read and write. A beginning has been made with such teaching and some small success has already been obtained. All the boys can read the foot-rule, fractions, whole numbers and mixed numbers from English type. Some of them have learnt also to read and write Persian in a moderate way: others are still in the difficulties of word-building. It is proposed to extend this more purely educational work to include arithmetic and general knowledge and, perhaps, also hygiene and games.

To recruit these boys and to keep them when recruited are not matters of mere plain sailing. The

recruitment is seasonal, the best period being between the first rains (in December or January) and March. One of the difficulties arose from the influx of bigger boys more suitable for employment as labourers than as learners in the workshop training school. "They belonged," says one who knows, "to the drifting class who come to the doors of the shop as the sparrows to the doors of houses when the cold weather forces them." From April to June there is apt to be an exodus of nomad types, especially among these bigger boys to whom the wandering life in summer still appeals; and most of the discharges effected at the boys' request take place at this period. This wastage of partly trained human material is not a light matter. In three years some 390 boys worked periods in the manual training school at Fields, for example, and then, at their own convenience, left to follow some "call of the wild" or other lure. The Company is giving anxious thought to the best means of retaining the suitable boys among those enlisted so as to turn them out as more or less skilled craftsmen fit for absorption by the engineering shops. It is obviously to the economic interest of the Company to stop this waste; it is, not less obviously, an economic asset to Persia that the number of indigenous skilled craftsmen in that country should be increased.

There can be no doubt that the coupling of the simple literary and arithmetical teaching with the manual training will have a steadying effect on the boys enrolled. But the Company has wider and more far-reaching schemes already initiated or under consideration, for the consolidation and improvement of this training of the young. A system of indentured apprenticeship in co-operation with the local government authorities is being considered, that may involve the housing, feeding and clothing by the Company of the apprentices. Moreover, the Company has already taken steps to extend the more purely educational facilities it provides. Two new elementary schools were being built and nearing completion at Fields which, when in full operation, may be expected to provide, in a less haphazard way, for entry into the manual training centres, boys who are less unstable and who have had some elementary education. These schools are, however, only parts of a much greater educational system established and fostered by the Company, and to this we must now turn our attention.

2. SCHOOLS

It was pointed out that the purely manual workshop training is hampered by the illiteracy of the boys and that, to make the workshop training more effective, steps have been taken to supplement the instruction by teaching the boys to read and write their native language.

There is, however, a further need for a more ambitious scheme of education than that covered by the instruction given in the manual training centres. It is the desire and the policy of the Anglo-Persian Oil Company to increase progressively the number of skilled Persians employed, whether as engineers, craftsmen or clerks, or in other skilled occupations. For such work there has been hitherto an inadequate supply of sufficiently educated Persians, having a competent, working knowledge of the English language. It is obviously desirable that, in a great industrial enterprise carried on in Persia, as much native skilled labour should be employed as is possible and practicable.

In order, therefore, to render the manual training more effective, and to assist the policy of "Persianising" the personnel, the Company has embarked on a wide and comprehensive scheme of general education,

THE COMPANY'S PRIMARY SCHOOL AT AHWAZ

with the approval of, and in co-ordination with, the Persian Government. At Masjid i Sueliman, as we have seen, two elementary schools were nearing completion. At Ahwaz the Company maintains entirely at its own cost a primary school and a secondary school. There is also an elementary school similarly maintained at Abadan. The writer was privileged to visit both the primary school and the secondary school at Ahwaz, and to see the normal instruction being carried out. As far as the elementary instruction is concerned, it may be taken as typical of that also given at Abadan and to be given at Fields.

The primary or elementary school at Ahwaz has about 140 boys whose ages vary from 9 to 16 years. They are all Persians, drawn from various classes. Entry into the school and the education given are free to all suitable boys, whether they be sons of the Company's employees or not. At Masjid i Suleiman, it should be mentioned, the schools are to be available and the education free, only for the sons of employees. To return to the Ahwaz primary school, it should be added that the pupils are also provided with school uniform, including boots and puttees. The medium of instruction is, of course Persian and English is also taught. The school is under the charge of the Persian head master, assisted

by a staff of six assistant masters, and the whole curriculum conforms to the scheme of the Persian Minister of Education. There is also a physical training instructor, and the school has a fife and drum band, constituted entirely of the boys.

The writer saw the whole school go through their physical exercises, under the direction of the physical training instructor. The smartness, the vim and the discipline shown would have been creditable in an English O.T.C. The exercises, it may be mentioned, by the way, are compounded of Russian and German methods of physical training, and are characterised by great rapidity in execution. The instruction in the class rooms covers the usual primary subjects, including the three R's; and many of the boys had made considerable progress in the reading of English. Their pronunciation was more than fair. Indeed, in this respect, they were less afflicted by "vowel complaint" than are the pupils of many a London school.

The secondary school at Ahwaz had only recently been opened in a building acquired by the Company and adapted to educational purposes. There were, in December, 1926, sixteen boys in the school under the charge of a head master, with two assistant masters as his colleagues—a ratio of masters to pupils which must excite the envy of many an English schoolmaster.

In time it is expected that the number of pupils in the school will be increased by the passage of suitable boys from the primary school, and the curriculum will be developed along the normal lines of secondary education. In this initial stage there is necessarily some duplication of the work done in the primary school.

The sanitary arrangements and the equipment of both the primary and the secondary school are good. There is a daily medical inspection and a keen watch is kept on the health of the pupils. In particular, it may be mentioned that there has been a marked improvement in "eye health"—an important benefit in a country where eye troubles are a common infliction, especially among the young.

It must be obvious that in the character and scope of the educational work just summarised, this Oil Company is performing functions comparable with, though less in extent than, those carried out by, say, a County or Borough Education Authority in England. How far the Company realises the value and importance of this work will be understood when it is added that an English educationist, of distinguished academic qualifications and educational experience, has been appointed and sent to Persia by the Company to direct, co-ordinate and develop these educational activities,

in sympathetic co-ordination with the Persian Minister of Education.

To the reader all this educational work must seem, at first impression, a far cry from the business of getting and refining crude oil. And yet the writer has failed in his purpose if he has not already made it clear that it has arisen as a natural—one might almost say, inevitable—outcome of the wide and far-seeing policy already noticed as directing the Company's diversified operations.

CHAPTER XVI

WORKSHOPS AND WORKERS

I. WORKSHOPS AND STORES

FROM a consideration of education and training we are led naturally to say a little of the workshops and stores of the Company and of the measures adopted to give to the workers a conscious and recognised status in the industrial scheme.

It has already been mentioned that at Fields, at Ahwaz and at Abadan the Anglo-Persian Oil Company has large engineering workshops. It would be wearisome, to author and reader alike, to enter upon a detailed description of each of these workshops, but some of the prominent features of the workshop at Fields may now be given, and be taken, as typical of those also at Ahwaz and Abadan.

Fields' workshops are situated at Chasmeh i Ali (the Spring of Ali) which is pretty nearly the geographical centre of the Masjid i Suleiman area. When the Company first came here, by the way, there was nothing but the spring; the rest was wilderness.

Fields workshops constitute great general repair shops and are under the charge of a European engineer, assisted by a staff of thirty Europeans, controlling some 420 mixed artisans, of whom some 300 odd are Persians. These workmen include fitters, turners, moulders, blacksmiths, carpenters, armature winders, general repairing electricians, boiler makers, welders (both electric and acetylene) and instrument makers. Among them are seventy-nine Indian engineers, to some of whom young Persians are attached as quasi-apprentices. To mention one instance that may interest the engineering reader, the writer saw a Persian boy, working skilfully at a No. 4 Herbert automatic lathe, whose sole occupation, but two years previously, had been that of a nomad driving the cattle to and from the hills and the desert.

There is a complete installation of the latest modern machinery, from the small instrument makers' bench lathe, weighing 2 lbs., to the huge 45 feet screw-cutting and surfacing lathe, with 14 inch centres. There are also universal milling, spiral gear cutting, automatic machines, operated by native Persians who have been trained by the Company. The operations in these workshops range from the repair of a delicate scientific instrument to the reconstruction of a steam tractor.

WORKSHOP AT FIELDS

engineering and building operations—the pipes, rails, girders, tractors, engines, well rigs, and the thousand-and-one other articles—but also, to meet the needs of the great number of Europeans employed, vast quantities of food, provisions, furniture, crockery and other domestic utensils have to be imported into the country.

The extensive stores at Fields, Ahwaz and Abadan have been constructed and laid out on modern scientific principles, and are equipped with up-to-date loading and transporting devices, in order to ensure the efficient storage and distribution of these varied products. The stores department at Fields, for example, is equipped with a 10 ton electric cranes and the railway from Dar i Khazineh to Fields runs into the stores yard, bringing approximately three hundred tons of material per month. The provision department distributes no less than £6,000 worth of stores per month. Attached to the stores is an ice factory, with modern refrigerating machinery, which manufactures 3½ tons of ice per day in the summer, and is capable of a daily output of 8 tons. Ample cold storage is provided and there is also a soda water factory turning out, on the average, 700 bottles of soda water per day. A staff of six Europeans, fifty clerks and 120 Persian labourers is needed to works

DRILLING STORES AT MASJID I SULEIMAN

Fields stores alone. The stores at Ahwaz and Abadan perform similar functions on a comparable scale.

It is their boast at stores, as it was Mr. Whiteley's boast, that they can supply anything. The writer accepted a challenge to put it to the test at Ahwaz. It is ungracious to tell the sequel but this is, in part, a historical record. The writer asked for a back collar stud, to replace one that had done faithful duty for fifteen years and then broke when he was as far from home as Persia. Alas! the stores failed. It is but fair to add that within an hour the Company provided him with a proper stud, but the source of its supply is still wrapped in mystery. It did not come from stores. The writer has an uneasy suspicion that he is still regarded at Ahwaz as one who did not play fair in asking for such an article.

II. GRADING OF THE WORKERS

We have seen that general education and manual training have been organised, and are to be extended and developed, in order to increase the supply of Persians suitable for employment in the various skilled occupations provided by the Company. There was, however, disclosed a need for further organisation when the workers have been educated and

trained. It should be realised that there are no trade unions in Persia ready to receive the workman out of his apprenticeship and to give formal recognition to his status and skill. We may leave aside, as beyond our purpose, all questions of the regulation, by collective bargaining or otherwise, of wages and hours of labour. There still remains, for the skilled worker, the need of a formal appraisement and recognition of the skill he has acquired. The English mechanic who has served his apprenticeship, to take a western example, is "hall marked" as a skilled artisan and his status as such is generally recognised. The Anglo-Persian Oil Company realised that it was not enough to train their Persian employees in the workshops or at the drilling rigs or elsewhere. It was necessary to make the skilled worker conscious of his status and to give him an interest and pride in maintaining and improving it.

A system of grading the workers according to their skill was, therefore, devised and has been in operation for some time. For each grade of workers there are prescribed and definite tests. When the worker has acquired the requisite competence in any one grade and has passed the prescribed tests he is given a corresponding certificate. He can secure promotion to a higher grade only by passing the requisite tests for

that grade. These certificates not only testify to the degree of skill reached by the worker, but also give him a recognised status, carrying with it a corresponding standard rate of pay. Moreover, a worker retains his certificate and if he should leave the Company's employment for a time, to taste nomad delights or for other reasons, and then seek re-engagement, he is recognised as eligible for employment in his certified grade.

According to the testimony received by the writer the Persian workers appreciate highly the value of this system of grading and guard it jealously. It is claimed that it fosters their self-respect, it gives them pride in their work and it provides them with incentives for improvement. It is an attempt to do for these initially unorganised Persian workers something of what the craft guilds did for English workmen from the middle ages down to recent times. The future development of this pregnant scheme will be a matter of great interest and moment. To the writer, and probably also to the reader, its most significant feature is the recognition, implicit in the scheme, that the self-respect of the worker and his pride in his work are of vital concern to the efficiency of any industrial system.

CHAPTER XVII

SOCIAL AMENITIES

SOMETHING should now be said of what is done for the social comfort and even the delight of the employees of the Company. For obvious reasons the need for some provision of this sort is greatest for the European employees, who are far removed from their homes and from the society, games and relaxations to which they may be presumed to have been accustomed. Altogether there are about 1,000 Europeans employed by the Anglo-Persian Oil Company in Persia. There are communities of about 350 at Fields, 500 at Abadan and seventy at Ahwaz; and smaller groups, widely dispersed, in varying degrees of loneliness, at the pumping stations, the rail-river head, the distant test areas and other outposts. The reader may be reminded that they who are here conveniently termed "European" are mainly British. Of the provision made for their health and housing something has already been said. It is with their gregarious needs that we are now concerned.

In the first place ample provision is made for games—cricket, football, hockey, tennis, squash racquets and golf. At Fields, for example, they run a football league and an annual international (England v. Scotland) football match; and they have no less than thirty-nine tennis courts, in the construction of which much ingenuity, not unmixed with science, has been shown. Grass courts are out of the question there; in the summer the grass is scorched up and in the winter it is too scant. The foundations of the tennis courts are made of "Kah-gil," a mixture of straw and mud, frequently used locally for the roofs of dwellings. Over this is a surface of sea shells which, when rolled, provides a durable court that plays fast and requires only systematic rolling to keep it in good condition.

Similar facilities for golf, football, cricket, tennis and squash racquets are provided at Abadan and also, for some of these games, at Ahwaz. Most, if not all, of the outlying stations have at least tennis courts. There is even a race course at Fields and the gymkhana clubs holds three or four race meetings a year. The writer attended one meeting held during his visit. It was run entirely by volunteers and was as well organised and furnished, down to the totalisator and the stray dog on the course, as a typical race meeting in England.

A FOOTBALL MATCH ON THE MAIDAN AT MASJID I SULAIMAN

At Abadan, Ahwaz and Fields there are clubs; spacious, well-built, and provided with such conveniences as lounge, billiard room, card room, reading room and usually, too, dance hall, fitted with stage and dressing rooms for theatrical performances. At Fields, for example, there are eight clubs to meet the social needs of both Europeans and others. The Anglo-Persian Oil Company, it should be said, provides the buildings, furniture, lighting and heating, and even the periodicals for these clubs, free of charge; for the rest the clubs must be, and are, self-supporting. Each club—and this applies equally to the sports clubs and to the gymkhana club—is run by its own committee. Tennis is free, but the other sports, such as golf, cricket or football, stand on their own financial feet.

A great central hall for Fields area has been recently built by the Company, and was formally opened last Christmas, at Chasmeh i Ali. It is available for the dances, concerts, theatrical and other entertainments that are organised from time to time by the various clubs in Fields area. In design, construction, accommodation and equipment, the building may well challenge comparison with elaborate halls for similar purposes in London. Last Christmas a pantomime—Dick Whittington—was produced there entirely by

local amateur talent, including a volunteer orchestra.

Nor have the more serious intellectual interests been overlooked. A lending library has been organised for the service of subscribing readers at Fields, Ahwaz and Abadan; and there are occasional lectures delivered by visitors and others on selected subjects. An attempt is made even to satisfy the modern craving for the daily paper; and a cyclostyled sheet or more of foolscap circulates daily the eclectic budget of news picked up by the wireless station at Abadan from the bulletin broadcast each day from Rugby in England.

The extent and the variety of all these social activities have led to the creation of a special social department, having its own office and its own full-time organiser, who acts also as a combined secretary and liaison officer for many of the club and society doings.

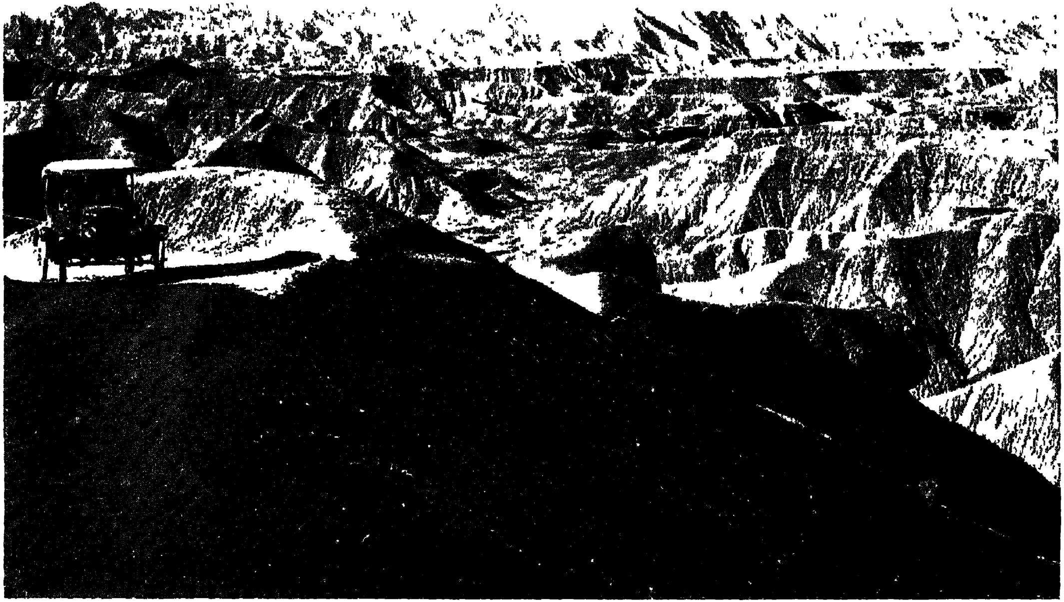
Lest the reader should think that this cursory record of the lighter side of things is beside our main purpose, it should be pointed out that these varied facilities for games, social intercourse and amusement are not merely the bountiful largesse of a munificent corporation. They are essential to the comfort, happiness and *esprit de corps* of the exiled Europeans more especially, on whom the main responsibility for the efficient working of the Company's multifarious

operations depends. They help materially to ward off that "staleness" to which every limited community of Europeans, more or less isolated in a foreign country, is liable.

It might seem on first thoughts that there need be no staleness in such a community as that at Fields, for example, where there are nearly 350 Europeans, including some forty ladies. Such a circle may seem big enough to many a Londoner whose acquaintances are few; but, however small a social circle in London may be, each member of it makes fresh contacts every day with wider circles, so that there is a constant social irrigation with fresh ideas, new topics and novel interests. The social circle at Fields, on the other hand, may be larger but it touches no wider circle outside it; the intellectual and social exchanges are confined for the most part to the same members; there is not the same opportunity for cross-fertilisation of ideas and topics. In such circumstances it is easy to see how a feeling of staleness may come to pervade the community and to take some of the zest out of life.

The games, the clubs, the concerts, the dances and other entertainments are valuable specifics against the growth of staleness and social ennui, quite apart

from their effect on physical health. From this point of view, therefore, they too may be regarded as properly belonging to a study of the scientific treatment of the human material in industry. They are, no less than the means adopted to minister to health and to provide good housing, direct aids to industrial efficiency.



ON THE GREAT ROAD FROM GANAWAH TO MISHUN, SHOWING THE TYPE OF COUNTRY THROUGH WHICH THE ROAD HAD TO BE BUILT

CHAPTER XVIII

SOME ECONOMIC FACTORS

BEFORE bringing this study in scientific and industrial development to a conclusion, an attempt should be made to summarise briefly some of the conspicuous economic and social benefits that have accrued to Persia through the operations conducted in that country by the Anglo-Persian Oil Company.

The economic and social advantages ensuing from the provision made, and described in the preceding pages, for the health, housing, education and training of the Persians need no elaboration. It is enough to say that to improve the health, to increase the efficiency and to raise the standard of comfort of a large section of the working population of any country are, perhaps, the most valuable and permanent forms in which contributions can be made to the real wealth of the country.

But there are other economic benefits to Persia, directly attributable to the work of the Company, such as, for example: improved transport facilities

by road making and other means; the direct revenue paid to the Persian Government by way of royalties, as well as contributions to local authorities for appropriate services; the creation of increased spending power by the distribution of a large wages fund; and the stimulation of production and the increase in volume and variety of the imports into Persia in order to meet enlarged demands for commodities. All these benefits are the tangible and intangible results of the work of the Anglo-Persian Oil Company in exporting from Persia the crude oil found beneath the surface and the refined products obtained from it. We may glance only cursorily at these factors.

No one who has visited the Middle East and seen the ceaseless caravans of asses, mules or camels, carrying their heavy loads over the desert or through the defiles of the hills, along rough tracks made only by the feet of countless, similar caravans through the ages, can fail to realise what an economic boon is a solid, unquestionable road. The Anglo-Persian Oil Company has constructed in Persia no less than 1,600 miles of roads. Many, perhaps most, of the Company's roads are among that twisted, crumpled foothills to which reference has been made and the construction of properly graded roads on such a terrain has called for great engineering skill and an enormous use of

THE DAR I KHAZINEH-FIELDS RAILWAY. BRIDGE OVER THE TEMBI RIVER

labour. The roads had to be made fit to bear heavy traffic and this has necessarily involved the building of numerous bridges. The road from Fields to Dar i Khazineh, for example, some thirty-six miles long, passes for the greater part of this distance through the Tembi valley, which is for long lengths a deep gorge; and the road has been blasted out of the steep sides of the gorge and crosses the river by several bridges. The Company employs, directly or through contract, some 4,000 Persians who are engaged constantly in making or maintaining roads.

Besides the road from Dar i Khazineh to Fields a railway of 2½ feet gauge, was constructed by the Company and opened in 1923. It follows also the Tembi valley and crosses the river by numerous bridges. Along this railway from 3,000 to 4,000 tons of material per month are transported, and the distribution of materials from the rail-river head, by road and railway combined, amounts to no less than 7,000 tons per month. Passengers are carried along the railway by means of a "Drury" car—a sort of open-sided, single-deck, tram car, driven by a petrol motor built into the chassis.

It is true that the main function of these roads is to serve the transport needs of the Anglo-Persian Oil Company, and that, apart from the employees of the

Company, there is no considerable local population, settled near the roads, to which they can be of great use. But they are generally available to all and are used to some extent by Persian non-employees. In any case, they constitute a valuable addition to the material assets of the country, both actually and potentially. Not only so, but by their very existence they provide an object lesson and an incentive to other areas, which may lead in time to improved road making and transport facilities in other parts of Persia.

The organisation and the control of the varied traffic along these roads is no light undertaking. For example, the total Fields transport fleet, including lorries and cars, is 467 vehicles; and for the whole of the transport operations in Fields area, taking into account the cars and lorries entering from other areas, approximately, 1,000 vehicles are used. There are similar transport fleets at Ahwaz and Abadan. It is worth notice that the motor lorries are equipped with a special device, called a "Controllograph," whereby there is automatically recorded on a circular paper dial the time taken, the speed, the rest periods and the distance covered for each journey of the lorry. The value of such a record for checking waste, loitering, furious driving and misuse is obvious.

The drivers of the cars and motor lorries are mainly Persians, including Arab and Armenian subjects of Persia, and most of them have been trained to their work by the Company. At Ahwaz, which is roughly the half-way house between Fields and Abadan, there is a great motor repair and overhaul shop where the cars and lorries are periodically vetted and put into working trim.

Incidentally it may be mentioned that in the busy area of Fields itself and also at Abadan the road traffic is controlled by Atashkaries, after the manner of the City police near the Mansion House in London. These Atashkaries, it should be explained, are Persian firemen, members of the Company's efficient fire brigade, and are trained under a European chief officer who was formerly chief of the fire brigade of an English borough. They wear a khaki uniform, with "shorts," and have a passion for saluting with the smartness of a British guardsman. There is even, in the centre of Maidan i Naftun, that most modern development, one-way traffic—maybe along the line of the very mule track that Alexander the Great traversed on his invasion of India. Such is the progress of the centuries.

In connection with transport mention should also be made of the fleet of shallow-draught, stern-wheel

paddle steamers that ply on the Karun river between Abadan and Dar i Khazineh and are the main means of transporting the heavy materials imported at Abadan and needed at Fields. It was explained that at Ahwaz, on the river Karun, some 114 miles by river from Abadan, there is a series of rapids. The Company has, therefore, to maintain two fleets of these boats, one to work the lower reach of the Karun river from Abadan to Ahwaz, the other to work the upper reach from above Ahwaz to Dar i Khazineh. The navigation of these steamers, which are oil fired and draw only from three to five feet of water, needs care, for the Karun river winds and twists unceasingly through the desert, is subject to great fluctuations of flow, and is beset with mud banks in its course. In times of flood the river frequently overflows its banks into the desert around for miles, and it shifts its course from time to time so that landing stages constructed at chosen points may be rendered useless.

Lastly, to complete this outline of transport facilities, bare reference should be made to the fleet of tankers that come to Abadan and Bawarda, on the Shatt el Arab, to take the crude oil to the Company's new refinery at Llandarcy, South Wales, and refined products from the Abadan Refinery to other destina-

tions. The tanker fleet now consists of eighty three ships (sixty-six in commission and seventeen building) of 750,000 dead weight tonnage, which combine all the modern improvements of this type of ship. To enable the largest of these tankers to be fully loaded at Bawarda, the bar of the Persian Gulf is being deepened by the Company, which, again, must be counted as an increased economic asset, potentially at least, to Persia.

It may be convenient to interpolate here a brief description of what the Anglo-Persian Oil Company has done in the way of developing means for the rapid and reliable communication of information between its scattered operating units. With vessels entering and leaving Abadan at the rate of ten per day, with exploratory tests being conducted in remote parts of Persia, and with the long pipe lines connecting the producing fields with the refinery, it will be obvious to the reader that reliable and speedy means of conveying information is a vital necessity. The Company has, therefore, developed an extensive system of telephones, telegraphy and wireless stations. There are two main wireless stations, one at Masjid i Suleiman and the other at Abadan, supplemented by five wireless installations, of shorter range, at other locations. These smaller stations are in touch with the

one or the other of the two main stations and thus a message from any one can reach (by being relayed, if necessary) any other station. There are no less than 375 pole miles of the telephone and telegraph system in constant use, the number of miles of telephone and telegraph wire needed to complete the service being at least six times the pole mileage.

In the case of the pipe lines, for example, that carry continuously, day and night, the crude oil from the wells to the refinery, communication by telephone and telegraph must be maintained between these centres and the pumping stations, for a break in the pipe line or an accident in a pumping station might involve a serious loss of oil, unless instructions could be issued immediately to cease pumping and to effect the necessary repairs. Moreover, messages are passing continuously over the telephone and telegraph lines, recording pressures, tank depths, temperatures and a hundred and one technical details, all of the utmost importance to the engineers responsible for the throughput. No patient in a hospital has such attention given to every throb and pulse beat as has this vital line. Without a telephone and telegraph system maintained in a high state of efficiency, the main pipe-line would be really more difficult to operate

than would a railway at home without its telephonic and telegraphic signalling system.

Again, in the course of testing the oil resources of the country, wells are sunk in far distant and almost inaccessible districts, with which continuous communication must be secured. The configuration, and at times the unsettled conditions, of the region between headquarters and these outlying test areas is such that land telegraph lines could be maintained only at prohibitive cost. The Company has taken full advantage of recent developments in radio science and has installed a system of wireless telephones and telegraphs which enables the prospectors in these test areas to communicate their needs to, and to receive instructions from, the principal wireless stations at the oil fields or at Abadan.

Similarly the long distance wireless station at Abadan—the greatest oil port of the East—enables the tankers at sea to communicate their due date at Abadan; berthing and loading instructions to be passed to the vessels while yet many miles away; and the pilots at the entrance of the Shatt el Arab to be warned in time. Thus, on reaching Abadan, the vessel comes without fuss or delay alongside her appointed wharf, where the shore staff are in readiness to connect the loading lines and hasten the vessel's despatch

to distant shores with her cargo of 10,000 tons of oil.

The telephonic, telegraphic and wireless installations are just as essential elements of the Company's equipment as are the pipe-lines, the pumps, the roads and the railway. They constitute, in a very real sense, the nervous system of this great industrial organism, by means of which the most distant parts are brought into instant and intimate touch with headquarters in Persia, and without which it would be impossible to co-ordinate to proper functioning the varied and scattered operations of the Company.

The direct contribution to the revenue of the Persian Government, paid in royalties and including dividends on the 20,000 shares owned by the Persian Government in the First Exploitation Company, from 1913 to March 31st, 1926, amounted approximately to 5¼ millions pounds sterling, the payments for the year ending March 31st, 1926, being in the neighbourhood of one million pounds. Since the total national revenue in 1924-25 amounted to a little more than 5½ million pounds, it is obvious that such substantial payments must relieve the tax payer in Persia of a considerable part of his tax burden.

In wages and local purchases the Anglo-Persian Oil Company pays out in cash in Persia some 2½

million pounds annually. The economic benefits of such a large wage distribution among the population cannot be confined to the wage receivers; the increased purchasing power spreads prosperity to the traders in the bazaars; it contributes its share to the general purchasing power of the nation as a whole; and it does something to stimulate production and to increase imports in order to meet the enlarged demands so created.

It may be of interest to note here that in order to guard against great fluctuations in the cost of living among the Persian workers, more especially fluctuations caused by wheat shortage, the Anglo-Persian Oil Company holds large reserves of wheat which can be unloaded on to the market when the price of that commodity rises so much as to be a real additional burden to the workers. In this way not only can immediate distress be met but prices and wages are steadied, to the mutual advantage of employer and employed.

It is worthy of remark that the present enlightened Shah of Persia has visited a great part of the area of the Company's active operations in Persia and that, last December, a number of Cabinet Ministers of the Persian Government made a similar visit. There is good reason to believe that the Shah and his govern-

ment are alive to the economic and social benefits accruing to Persia and the Persians from this great industrial enterprise and that, in particular, they welcome the policy of the Company in seeking to increase the co-operation of Persian subjects in the varied operations of the Company.

In this connection it may be mentioned that it is the custom of the Anglo-Persian Oil Company to issue in Persian the annual general report of the Company as well as Persian translations of other selected publications. In this way an intellectual interest is created and maintained among educated Persians in the progress and development of an industry of vital economic significance to Persia. Nor does this intellectual entente, if it may be so called, end here. At home lectures are delivered from time to time before appropriate societies, and articles contributed to magazines and institutional journals, by officials of the Company, and notably by Sir John Cadman and Sir Arnold T. Wilson, on subjects relating to Persia, with the object of familiarising English audiences and readers with Persian achievements, ideas and aspirations. Apart from the inherent interest of lectures and articles of this sort, their psychological effect, there is reason to think, is not negligible.

Much more might be said, of course, were more

space available, on the economic results of the activities in Persia of the Anglo-Persian Oil Company. Enough has been said, perhaps, to make it not altogether a wild hope to entertain, that the record here given may help to dispel the notion, sometimes held and expressed at home, that the work of any great industrial undertaking can be dismissed airily under the contemptuous term of exploitation.

CHAPTER XIX

CONCLUSION

In the foregoing pages an attempt has been made to show broadly, without too much technical detail, the extent to which the Anglo-Persian Oil Company has applied, and is applying, scientific knowledge, research and methods to its activities, more especially in Persia. There are some outstanding features of this aspect of its work to which attention should now be directed.

In the first place it will have been recognised that the distinction often drawn between pure science and applied science has no practical significance in the determination of the Company's operations. To elucidate the scientific principles involved, to gain the scientific knowledge needed, and to apply the knowledge, in so far as it can be applied, to industrial practice, these aims are regarded as constituting essentially one problem and one purpose.

In the second place, science is not confined, as too often in industry it is, to a strictly limited technical

area, nor is it regarded merely as the Hercules standing by to get the industrial waggon out of the rut. There are no limits set to the field in which science, or at least some of the methods of science, may be applied; and the scientist is adopted into the industrial family as a working member of the household, on equal footing with the other members, such as the business man, the financier or the administrator. It follows that the problems presenting themselves successively for solution are seen steadily and seen whole—to borrow Matthew Arnold's phrase—from a standpoint that includes the view of the man with the pick and also the view of the man with the test tube. The merging of these two outlooks and the co-operation of the corresponding personalities provide an example well worth study of how science can be well—perhaps best—assimilated into the industrial organism. It is of more than passing interest to note that this unreserved acceptance of the roles of science and the scientist in industrial development culminated in the recent appointment to the Chairmanship of this great corporation, by the unanimous vote of his fellow Directors, of Sir John Cadman, whose previous experience combined that of a distinguished university professor with that of a mines manager familiar with the face of the coal seam.

Another notable feature that can hardly have escaped the reader's attention is the comprehensive character of many of the researches undertaken—for example, on the methods of oil finding; the study of pressures and levels; the problem of the gas; the correlation of investigations into engines and engine performances with those into the oil to be used in the engines; and the investigation of tropical and industrial diseases. It may possibly be argued, at first blush, that a company having the large financial resources of the Anglo-Persian Oil Company can well afford to take such a comprehensive view of research needs. Whatever truth there may be in such a contention, the argument fails to take into account how much these large financial resources are due to the general adoption of such a wide and far-seeing policy.

Such are some of the broader considerations that arise on a general survey of the more strictly scientific side of the Company's work. It is, however, impossible fitly to conclude this essay without a wider glance at what in effect the Anglo-Persian Oil Company has done in Persia.

Before the Company came to Persia the area around Masjid i Suleiman was little else than a wilderness of crumpled hills, the loneliness of which was disturbed only by the wandering nomads or by the prowling

hyænas and jackals. There were no roads. There were only mule tracks which the nomadic tribes with their flocks and herds traversed twice a year on their way to the growing grass. A few rude habitations provided shelter for the relatively few Persians that tilled the soil to be found here and there in favourable valleys and, having reaped their meagre crops, then moved on.

To-day, among these same treeless hills, over an area of about 200 square miles, there is a settled industrial population of some 30,000 souls, provided with all, or nearly all, the conveniences and amenities of western civilisation—good roads with motor transport; a light railway; electric light and power supply; pure water supply; natural gas; excellent housing accommodation, from the spacious bungalows for the higher British staff to the rows of solid houses for the Persian labourers; substantially built and sanitary bazaars, including bakery and baths; a more than well equipped hospital; modern sanitation; skilled medical and surgical service; telegraph and telephone service; wireless station; fire brigade; schools and workshop training centres; clubs and a central hall for concerts and other entertainments; playing fields, tennis and racquets courts, golf links and—even—a racecourse.

Dotted here and there in Fields are the derricks which mark the spots whence is drawn from below that dark liquor, the crude oil, which is the very life blood and sustenance of this elaborate civilisation and also of the similar and larger community, a hundred and fifty miles away, at Abadan. Round about on the gaunt hills are the ever burning, mighty flares, pillars of cloud by day and gigantic torches by night, that witness to the enormous store of energy beneath this part of the earth's crust and themselves provide fresh problems of the conservation and use of this energy, problems which call for further sustained, scientifically directed, human effort.

A not less remarkable transformation has been effected at Abadan and Bawarda, on the island of Abadan, at the head of the Persian Gulf. Before the Anglo-Persian Oil Company began to construct its refinery here, the land was a waste patch of mud desert, breaking the continuity of the palm groves that line both sides of the Shatt el Arab from above Basra to near the bar of the Persian Gulf.

To-day there is a community of some 50,000 souls at Abadan, which has, excepting the railway and the flares, practically everything—and more—to be found at Fields and, when the writer was there in December, 1926, an expert botanist was studying the problem of

the most suitable trees, shrubs and plants to be selected for the adornment of a public park already under construction. Abadan and Bawarda, moreover, form a great shipping port—"the Swansea of the East"—with loading jetties, thrust out into the deep water of the Shatt el Arab, to which and from which come and go the great tankers of a mighty fleet, as well as the shallow-draught river craft that ply on the home waters.

To watch the current of life flow and reflow, day by day, through these varied channels, and to reflect that but a few short years ago there was nothing at Fields but a hilly wilderness and at Abadan only a bare desert, is to realise what a great thing has been done for Persia, for Britain and for civilisation in this area of the Middle East. It is inspiring to remember that all these results have come from British enterprise, industrial organisation and, not least of all, from the steady, persistent application, continuously directed from the head, of scientific knowledge and methods to the whole business of getting and refining a black liquid from the bowels of the earth.

The writer is not disposed to qualify the exalted view expressed to him that what the Anglo-Persian Oil Company has done in Persia is one of the finest achievements associated with the British name. It is

a great game finely played, and the spectator must be dull who is not thrilled by it and apathetic if he does not feel, while watching the game, some longing to be a participator in it.

Corporations, it is said, have no souls. One might as well say that schools have no tone or that the spirit of a university is a meaningless phrase. It would be truer and better to say that every corporation has a soul, cramped or spacious, mean or generous, short-sighted or far-sighted, darkened or enlightened. The decisive test, as John Morley pointed out years ago in reference to nations, is the height and amplitude of the issues engaged and whether they are pursued intrepidly or "with creeping foot and blinking eye." The reader must judge how far the Anglo-Persian Oil Company comes to meet this exacting test.

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